American University in Cairo

AUC Knowledge Fountain

Theses and Dissertations

2-1-2017

Does trade liberalization lead to specialization in dirty industries? A CGE assessment for Kenya

Charles Kariuki Muthuthi

THESIS TITLE PAGE

The American University in Cairo

School of Business

DOES TRADE LIBERALIZATION LEAD TO SPECIALIZATION IN DIRTY INDUSTRIES?
A CGE ASSESSMENT FOR KENYA

A Thesis Submitted to

Department of Economics

in partial fulfillment of the requirements for
the degree of Master of Arts in Economics

by **Charles Kariuki Muthuthi**

under the supervision of Dr. Abeer Elshennawy

January, 2017

{Form IV: Thesis Signature / Approval Page}

The American University in Cairo

Thesis Title

DOES TRADE LIBERALIZATION LEAD TO SPECIALIZATION IN DIRTY INDUSTRIES? A CGE ASSESSMENT FOR KENYA

A Thesis Submitted by

Full Name of Student (as written on graduation certificate)

MASTER OF ARTS IN ECONOMICS

To the DEPARTMENT OF ECONOMICS Program

Month/ Year

JANUARY/2017

In partial fulfillment of the requirements for
The degree of Master of Arts or Science (choose one)

Has been approved by

Thesis Committee Supervisor/Chair A. Shunnay

Affiliation Economics

Thesis Committee Reader/Examiner Samer Atallah

Affiliation Economics/AUC

Thesis Committee Reader/Examiner Ahmed Rashed El Safty

Affiliation Visiting Associate Professor of Practice Department of Economics

Thesis Committee Reader/External Examiner N/A
(if required by dept.)

Affiliation

	11/1/2017		
Dept. Chair/Director	Date	Dean	Date

DEDICATION

In Memory of My Son,

Michael Nyaga Kariuki

(2003-2014)

ACKNOWLEDGEMENTS

The completion of this thesis could not have been possible without the contributions of many people. My love and gratitude go to my wife, and the rest of my family, for supporting me in many ways, including their understanding for my lengthy absence from home, during my graduate studies at the American University in Cairo (AUC). The finalization of this thesis was made possible by the continued, and untiring support by my thesis supervisor, Dr. Abeer Elshennawy. Dr. Elshennawy's patience in working with me is highly appreciated. Many thanks go to the rest of my thesis advisory committee: Dr. Samer Atallah, and Dr. Ahmed El Safty. I express my deepest appreciation for the guidance and advice that my thesis advisory committee provided me over the course of this project. My sincere gratitude go to Dr. Adel Beshai, Professor of Economics and Director of Graduate Studies. Dr. Adel Beshai, encouraged me to embark on this most rewarding journey, and has guided me along the way. I am also deeply indebted to the rest of the faculty and my colleagues at the Economics Department of the AUC. Special thanks go to Ms. Amira Bishara and Ms. Heba Halim for their invaluable administrative support, and to Ms. Heba Halim, in particular, for her assistance during the course of my thesis research work. A big thank you, to my many friends, who have supported me, in many ways, over the course of my studies at the AUC. Furthermore, I am extremely grateful to have been a recipient of a research grant from the AUC's School of Business that facilitated the completion of this study. Last, but not least, I send big thanks to the Kenya National Bureau of Statistics (KNBS), for granting me access to the Kenya's 2009 balanced micro Social Accounting Matrix (SAM), that made this research possible.

ABSTRACT

The dearth of empirical evidence across developing countries on whether trade liberalization would lead a country to specialize in dirty industries to exploit its comparative advantages in trade, motivates this thesis. The thesis uses the case of Kenya, —a lower-middle income country with the largest economy in Eastern Africa— to investigate two fundamental questions: (i) will Kenya's realization of its comparative advantages in trade, relative to those of its neighbors, heighten the risk of specialization in dirty production? and (ii) will Kenya's trade competitiveness be adversely impacted by its implementation of an environmental tax that directly targets polluting energy inputs? Compared to a 2009 base-run, the impact of three alternative ex-ante policies were quantitatively evaluated: further trade liberalization, alone; pollution abatement, alone; and joint implementation of these policies. A static computable general equilibrium (CGE) model for Kenya, that is theoretically founded on the tradition of CGE models for open developing economies by the World Bank (Dervis, et al., 1982), was developed to investigate these fundamental issues. Deepening Kenya's trade liberalization, alone, was found to have beneficial effects on output, with the risk that the country could intensify its specialization in dirty industries. In comparison, an environmental policy in the form of a tax on energy inputs, alone, reduced pollution in energy-intensive industries, but was costly in terms of falling output. Potential worsening of Kenya's environmental situation might, nevertheless, be mitigated without adversely affecting output through a mix of policy interventions. In conclusion, even if political commitments for a cleaner environment were in place in Kenya, which is far from certain, further trade liberalization without concrete policy interventions to abate industrial pollution, might create or exacerbate environmental degradation.

Keywords: Kenya; trade liberalization; environmental tax; dirty industries; CGE.

TABLE OF CONTENTS

LIST OF CHARTS AND TABLES

Charts

Tables

LIST OF FREQUENTLY USED ABBREVIATIONS

Acronym	Meaning
ASEAN	The Association of Southeast Asian Nations
CAGR	Compound annual growth rate
CES	Constant elasticity of substitution
CET	Constant elasticity of transformation
CGE	Computable general equilibrium
CH4	Methane
CO2	Carbon dioxide
CO2e	CO2 equivalent
COMESA	Common Market for Eastern and Southern Africa
EAC	East African Community
EKC	Environmental Kuznets curve
EU	European Union
FDI	Foreign direct investment
GAMS	General Algebraic Modeling System
GDP	Gross domestic product
GHGs	Greenhouse gases
GTAP	Global Trade Analysis Project
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
KenCGE	Kenya's CGE Model in GAMS
KenSAM	Kenya's Social Accounting Matrix
KSh	Kenyan Shillings
LULUCF	Land use, land use change, and forestry
MtCO2e	Million tons CO2 equivalent
NAFTA	North American Free Trade Agreement
NCCAP	National Climate Change Action Plan
NEMA	National Environment Management Authority
NMVOC	Non-methane volatile organic compounds
N20	Nitrous oxide
NOx	Nitrogen oxides (nitric oxide, NO, and nitrogen dioxide, NO2)
OECD	The Organization for Economic Co-operation and Development
PM	Particulate matter
RoW	Rest of the world
SAM	Social accounting matrix

Acronym	Meaning
SO2	Sulfur dioxide
UN	United Nations
UN ESA	United Nations, Department of Economic and Social Affairs
UNFCCC	United Nations Framework Convention on Climate Change
US	United States of America
US$	United States dollar
WTO	World Trade Organization

CHAPTER I: INTRODUCTION

1.1. Overview

A controversy over the linkages between trade opening and environment quality emerged in the early 1970s leading to the incorporation of environmental concerns in the agreement of the Uruguay Round (1986-1994) of the General Agreement on Tariffs and Trade (GATT) (Beghin, et al., 1994)[1]. The discussion pits environmentalists, who argue that intensification of economic activities inevitably contribute to environmental degradation and likely ecological demise, against trade economists, who contend that the process of achieving economic progress itself will eventually resolve environmental problems (Shafik, 1994). Developing countries with outward-oriented economic policies are said to reap a relatively higher dividend from globalization (Beghin, et al., 2002b:3-14). On the contrary, however, critics of globalization contend that it quickly manifests itself in depletion of finite natural resources, degradation of biodiversity, and intensification of pollution (Kirkpatrick and Scrieciu, 2008:497). Above all, globalization, and trade, if not the main cause of, are key contributors to, environmental damage (Nordström and Vaughan, 1999; Beghin, et al., 2002b:3).

The discourse on free trade-environmental quality nexus is relevant in the case of Kenya. Graduated only recently to the lower-middle income status by the World Bank, the country has the largest economy in Eastern Africa, and in 2015 was ranked 8th in Africa in terms of nominal Gross Domestic Product (GDP). A founder member of the World Trade Organization (WTO), Kenya is a major player in free trade initiatives in the East African Community (EAC), and the Common Market for Eastern and Southern Africa (COMESA). Kenya's trade openness ratio fluctuated between 52.2% and 64.6% over the 1961-2009 period (Musila, et al., 2015)[2] and, according to the World Bank (2016), averaged 52.5%, as a percentage of GDP, during the 2009-2015 period. To deepen its

[1] Also see: "The environment: a specific concern" and "Trade and environment in the WTO". World Trade Organization (WTO, 2016). Available at: https://www.wto.org/english/.

[2] Musila, et al. (2015) define trade openness ratio as a quotient between the sum of exports and imports and GDP.

trade opening agenda, in September 2016, Kenya signed a free trade pack with the European Union (EU), under the auspices of the EAC. Hence, Kenya's trade openness ratio is bound to rise further because of these trade-opening initiatives. On the whole, the Kenyan economy is highly sensitive to trade liberalization reforms.

Kenya's real GDP growth accelerated to 5.6% in 2015, up from 3.3% in 2009 (International Monetary Fund (IMF), 2016), thanks to its outward-oriented economic policies. In 2014, the agriculture sector ―that provide essential raw materials for industrialization―, and the manufacturing sector, contributed 30%, and 11%, respectively, to Kenya's real GDP (World Bank, 2016). Regarding the contribution to value-added in production, the leading sector is services, followed by agriculture, and then industry. Kenya's outward-oriented economy is ubiquitously market driven, across products, factors, capital, and foreign exchange markets. There are structural bottlenecks, however. Unfavorable terms of trade shocks have caused Kenya's current account deficit, as a percentage of GDP, to widen from 4.6% in 2009 to 8.2% in 2015 (IMF, 2016) and, furthermore, the country's overall unemployment rate stands at about 9% (World Bank, 2016), and is even higher among the youth.

Kenya's economic development is driven, mainly by its comparative advantages in trade, factors, and natural resources. With regard to the latter, the country stands ready to exploit its recently discovered coal and oil reserves[3] to further drive its economy to a solid middle income status by 2030. Clearly, this will have major environmental consequences. Nevertheless, there is heightened civil society activism, that builds on the Wangari Maathai (1940-2011) ―the 2004 Nobel Peace Prize Laureate―, who called on her fellow Kenyans, and Africans in general, "to take charge of their environment" (Green Belt Movement, 2015).

[3] Kenya has recently discovered recoverable oil deposits and is building a 960 MW coal-fired power plant in its coastal city of Lamu (Kant, et al., 2014). Exports of oil is planned to commence in mid-2017 (see article by Bloomberg, "Kenya From Nowhere Plans East Africa's First Oil Exports: Energy" at: http://www.bloomberg.com/).

At present, Kenya is a low emitter of greenhouse gases (GHGs). However, the risks of environmental degradation are rising because of a growing population at 2.7% per annum, a demographic shift towards urban that is estimated at an annual rate of 4.15% over the 2015-2020 period (United Nations, Department of Economic and Social Affairs (UN ESA), 2014), and a rapid pace of economic and infrastructure developments. Data by the World Bank (2016) show that the proportion of Kenyan population exposed to particulate matter, PM2.5 air pollution[4] that exceed the World Health Organization (WHO)'s guidelines, increased significantly, from 43.9% in 1990 to 59.8% in 2013. This is as PM2.5 air pollution rose by 8.9% between 2000 and 2011 (World Bank, 2016). Over the same period, emissions of carbon dioxide (CO_2) increased by 30.2%, those of nitrous oxide (NO_2) by 24.1%, and methane (CH_4) by 24.5% (World Bank, 2016). The growth of emissions from the energy and transportation sectors is projected to add 43 $MtCO_2eq$ (million tons CO_2 equivalent) of GHGs by 2030, compared to the situation in 2013 (Kant, et al., 2014). A major contradiction is that while the country's National Climate Change Action Plan (NCCAP) envisages a low-carbon economy by 2030, Kenya's Vision 2030 aims to drive industrialization through higher utilization of fossil fuels for electricity generation (Kant, et al., 2014).

With freer trade, and given the classical theory of trade, a country might specialize and expand economic activities in the area where it has a comparative advantage in trade (see Kirkpatrick and Scrieciu, 2008:498). Cross-country empirical evidence concerning whether a country might specialize in dirty production to exploit its comparative advantages in trade is, however, lacking in many developing countries. In Mexico, unilateral trade liberalization under the North American Free Trade Agreement (NAFTA) was associated with a 3.2% rise in real GDP, and a 2.5% to 4.8% rise in all major pollutants (Beghin, et al., 1995). Results that are more drastic were found for Costa Rica, where comparative advantages in polluting sectors increased emissions by 15%-20% as trade flows rose significantly, compared to a 2010 benchmark scenario (Dessus and Bussolo, 1998).

[4] Particulate matter (PM) —also known as particle pollution—, comprise of tiny pieces of solids or liquids that are found in the air, and if less than 2.5 micrometers, are harmful to human health when inhaled.

These outcomes suggest that trade opening damages the environment. If this were the case, major concerns could emerge in Kenya, given the country's economic transformative agenda that is shifting the economy towards agroindustry manufacturing. As discussed further in Chapter III, already, 17% of Kenya's exports are in energy-intensive activities with significant industrial emissions. As Kenya pursues the benefits of globalization in the context of the planned oil production and exports starting 2017, its primary energy sector, and energy-intensive manufacturing, are bound to expand significantly in the short-term. This poses the risk that the country's production techniques might turn dirtier. Besides, given a growing population, and urbanization, harmful emissions from the consumption of fossil fuels would rise. If so, this is bound to pose rising and substantial public health risks, in the backdrop of an already highly polluted urban transportation system.

Kenya, compared to its neighbors, has relatively higher factor endowments, including capital. This, combined with weak environmental regulations is fertile ground for "pollution havens" (see Copeland and Taylor, 2004; Cole, 2004; Cole and Elliott, 2005; Kuik and Gerlagh, 2003)[5]. Consequently, expanding productive activities could turn inefficient, dirtier, or worse, make Kenya a "pollution haven". But, if Kenya implements tough pollution abatement policies, the marginal costs of production are likely to rise significantly. This in turn could adversely undermine the country's current export competitiveness. An environmental tax on polluting consumer goods could be imposed but such a policy might significantly raise the prices of the targeted goods; this is a politically sensitive issue. Does this suggest that Kenya has the incentive to specialize in dirty industries? If this were the case, Kenya's policy makers could be faced with trade-offs between further trade liberalization and environmental quality; economic growth being inimical to the environment, and environmental policy being detrimental to economic growth objectives (Beghin, et al., 2002b:12).

[5] The 'pollution haven' hypothesis hold the view that polluting industries in industrialized economies where environmental standards are high will relocate to lax regulatory jurisdictions.

Presently, academic literature offers very little guidance to Kenya's policy makers on these fundamental questions. The problem, with the current state of knowledge, is that each developing country is faced with its own unique context on environment-trade nexus. Beghin, et al., (2002b13) argue that the agenda for research in this area is huge, and policy designers need to be informed by "case-by-case" empirical scrutiny. To close the gap in the academic literature, this thesis employs a quantitative approach to investigate whether the hypothesis of a trade-off between trade liberalization and environmental quality might be supported in the case of Kenya. If this were the case, then a higher level of environmental quality might imply a trade-off in terms lower real GDP growth rates. Conversely, economic growth itself might partly be driven by deepening international trade, but at higher environmental costs to Kenya. Empirical support for such a finding might incentivize Kenya's policy makers to take concrete steps to mitigate probable environmental damage that may arise from further trade opening. Finally, Kenya presents a good case for testing these trade-environment linkages, as reliable, relevant, and recent data is available.

1.2. Problem Statement and Objectives

1.2.1. Specific problem

This study is motivated by the dearth of robust empirical evidence on whether there exists a trade-off between further trade openness and environmental quality in developing countries, and specifically, Kenya. Using a static computable general equilibrium (CGE) model, it aims to bridge this gap in knowledge by quantitatively evaluating the interdependencies between Kenya's trade liberalization and emission abatement policies. The study's goal is to provide evidence on whether the hypothesis that developing economies tend to specialize in dirty industries to exploit their comparative advantages, is supported in the case of Kenya.

1.2.2. Objectives of the study

This research employs a theoretically founded CGE model, that is founded on a reliable database, to quantitatively investigate whether a trade-off exists between trade openness and environmental quality in the case of Kenya. Kenya's push to deepen trade liberalization over time, and its willingness to exploit its relatively significant comparative advantages in factors of production and natural resources to drive its industrialization agenda as defined in its Vision 2030, is viewed as an incentive for the country to specialize in dirty production.

To respond to these issues, a 2009 baseline scenario is defined. The objective is to evaluate the quantitative *ex-ante* impacts of three alternative policy goals **—**further trade liberalization, alone; an environmental tax, alone; and free trade and an environmental tax, jointly**—** over the short-term compared to the 2009 base-run.

The question of whether the assumed trade-off between trade liberalization and pollution abatement does incentivize developing countries, like Kenya, to specialize in dirty technologies leads to further questions. Will Kenya's realization of its comparative advantages increase the risks of the country specializing in dirty production? Will the implementation of a policy of taxes on energy inputs adversely affect Kenya's international trade competitiveness? Specific questions that this thesis will aim to address, are:

- What is the impact of further trade liberalization policy, alone, on the pattern of specialization?
- What is the impact of implementing an environmental tax policy, alone, on competitiveness?
- What is the impact of joint implementing of further trade liberalization policy, and an environmental tax policy, on competitiveness and pattern of specialization?

1.3. Organization of this Thesis

The rest of this thesis is organized as follows. Next is Chapter II that reviews the theoretical and empirical literature concerning the linkages between trade, economic growth, and the environment. The Chapter also outlines the outcomes of select econometric and modeling techniques used by researchers to assess the trade-off between trade liberalization and environmental quality, and importantly, the methodological choices that are available for conducting such quantitative analysis.

Thereafter, Chapter III contextualizes this thesis by presenting Kenya's economic, trade, foreign direct investments flows, and environmental indicators, and analyzing how these have evolved in the recent decades. Kenya's quest to capture the dividends of globalization through exploitation of its comparative advantages in trade is analyzed in the backdrop of intensification of industrial emissions that such global driven growth may cause.

This is followed by Chapter IV that presents the static computable general equilibrium (CGE) model for Kenya in GAMS (General Algebraic Modeling System) software ―the KenCGE Model― that is used to conduct the quantitative analysis.

Chapter V introduces the different experimental scenarios that are employed in the analysis to address the objectives of this study. The Chapter also presents the outcomes of this thesis. These include the patterns of Kenya's trade specialization with deeper trade opening, and the environmental implications of such changes.

Finally, Chapter VI concludes this thesis with a discussion on key take away messages, limitations of the study, and suggestions for further research.

CHAPTER II: LITERATURE REVIEW

Chapter two presents a review of the theoretical and empirical literature underpinning the relationships between economic growth, international trade, and the environment. An introductory review is provided in Section 2.1 regarding the relationships between trade and growth, on the one hand, and higher economic growth and environmental quality, on the other. Section 2.1, also outlines the theoretical perspectives relating to the main channels through which freer trade impacts the environment. Thereafter, Section 2.2 summarizes the key outcomes of econometric and modeling techniques that researchers have employed to assess the trade-off between trade liberalization and environmental quality. Next is Section 2.3 that covers the methodological choices that are available for use in this thesis. Finally, Section 2.4 makes concluding remarks.

2.1. Theoretical Literature

2.1.1. Trade, growth, and the environment

Literature contends that increased international trade foster growth, but also intensifies pressures on the environment. In this regard, the links between trade and growth have fascinated scholars since David Ricardo, in his 1817 publication "*On the Principles of Political Economy and Taxation*" proposed his classical theory of comparative advantage[6]. Building on the Ricardian theory of comparative advantage, Eli Heckscher and Bertil Ohlin, proposed their influential general equilibrium, Heckscher–Ohlin (H–O) Model of international trade (see Feenstra, Robert C., 2004; Leamer, Edward E., 1995), asserting that a nation's factor endowments drive international trade. If countries have access to similar production technologies, the H–O Model predict that a country's production and exports will be driven by its abundant and cheap factors, and imports by its scarce factors.

---

[6] The Ricardian theory on comparative advantage was in stark contrast to doctrine of absolute advantages that Adam Smith had earlier proposed in his 1776 publication, *"The Wealth of Nations",* as the basis for international trade.

A major phenomenon that shaped international trade is the wave towards regionalization of trade, which commenced with the launch of the European Economic Community in 1957. The decade and a half ending 2000 marked a reinvigorated interest by countries to negotiate and sign agreements on regional economic blocs to draw benefits of membership, including gains from trade (World Bank, 2000). The collapse, in 2008, of the Doha round of trade negotiations that had commenced in 2001, created a new impetus for countries to strengthen their regional trade agendas. In this regard, Africa signed several trade agreements to further deepen regional trade and investments[7]. The pursuit of trade specialization to exploit country comparative advantages fueled the growth of globalization. Consequently, the heated discussions regarding the linkages between economic growth and the environment that had emerged in mid-1960s (Kågeson, 1998) intensified. The discussions were redirected to the linkages between trade opening and environment quality, in the early 1970s, leading to the incorporation of environmental concerns in the agreement of the Uruguay Round (1986-1994) of the General Agreement on Tariffs and Trade (GATT) (Beghin, et al., 1994). It was, however, not until the 1990s when the World Trade Organization (WTO)[8] took over the leadership on trade-environment linkages that more focused discussions emerged relating to the effects of trade on the environment (see Beghin, et al., 2002b:3; Kirkpatrick and Scrieciu, 2008:497).

Daly (1973) in "*Toward Steady-state Economics"* publication, favor the minimum feasible physical production and consumption levels to contain the ever-rising demand for finite natural resources. The alternative, that is supported by other scholars, including Beckerman, W. (1974), view economic growth as an accelerator for efficiency in the production processes. As a result, growth is said to foster substitution possibilities, away

[7] Africa's regional economic blocs are: Arab Maghreb Union (UMA); Common Market for Eastern and Southern Africa (COMESA); Community of Sahel-Saharan States (CEN-SAD); East African Community (EAC); Economic Community of Central African States (ECCAS); Economic Community of West African States (ECOWAS); Intergovernmental Authority on Development (IGAD); and Southern African Development Community (SADC).

[8] The predecessor to the World Trade Organization (WTO) was the General Agreement on Tariffs and Trade (GATT) that was a multilateral agreement regulating international trade. WTO was launched at the end of the Uruguay Round (1986–1994) of trade negotiations (WTO, 2016).

from outdated and environmentally unfriendly technologies, to eco-friendly technologies. The trade liberalization-environmental quality controversy, overall, pits environmentalists who argue that the intensification of economic activities, inevitably contribute to environmental degradation, and likely economic and ecological demise, against trade economists, who contend that the process of achieving economic progress itself will eventually, resolve environmental problems (Shafik, 1994).

In brief, although developing countries with outward-oriented economic policies are said to reap relatively higher dividend from globalization (Beghin, et al., 2002b:3-14), opponents argue that globalization quickly manifests itself in depletion of finite natural resources, degradation of biodiversity, and intensification of pollution (Kirkpatrick and Scrieciu, 2008:497). If not the main cause of environmental damage, then globalization and trade, are major causes of environmental degradation (Nordström and Vaughan, 1999; Beghin, et al., 2002b:3).

2.1.2. Transmission mechanisms

The channels through which freer trade impacts the environment, are both indirect, and direct. A trade liberalization policy might indirectly impact the environment through the direct effects of freer trade on economic growth (see Kirkpatrick and Scrieciu, 2008:499). Trade opening directly influences a country's economic growth performance, by subjecting domestic firms to international competition. In this case, globalization, over time, enhances productivity of labor, through access to recent technologies. In turn, higher labor productivity improves efficiency of firms, and enables countries to exploit their comparative advantages, and intensify exports. This way, economic growth, itself directly impacts environmental quality, and consequently, through economic growth, trade has indirect effects on environmental performance. This indirect channel through which trade affects the environment is founded on the theory of the *environmental Kuznets curve* (EKC). Inspired by the work of Kuznets (1955), the ECK theory is credited to the independent works by Panayotou (1993), Grossman and Krueger (1993), and Shafik and Bandyopadhyay, (1992)[9]. The ECK hypothesis suggests that the relationship between different types of pollutants and per capita incomes, is shaped as an inverted-U (Kågeson, P., 1998).

In theory, the EKC hypothesis suggests that as income rises, pollution increase at low per capita income, reaches a turning point, and thereafter declines at higher per capita income. Lower degrees of environmental awareness characterize the initial stages of industrialization, as the public is more preoccupied with having jobs and incomes to meet their basic needs (Dasgupta et al., 2002). This, coupled with weak environmental regulatory capacity, causes intensification of industrial pollution, and consequently, the EKC rises rapidly. Nevertheless, industrial pollution diminishes when income levels surpass a certain threshold, the citizenry concerns for cleaner environments mounts, and there is capacity to enforce environmental standards (Dasgupta et al., 2002). Grossman and Krueger (1995), using urban air pollution, and three river basins contaminants ―dissolved oxygen, fecal, and heavy metals―, found support for the EKC, and observed that the turning point took place before a country attained a per capita income of US$8,000 – US$10,000 (in 1985 dollars). Although the EKC hypothesis may be a useful tool for explaining how growth, and consequently, trade, could impact emissions over time, it is important to underscore that the nexus between growth, trade and pollution is multifaceted. Trade and growth are intertwined through complex policy and institutional arrangements. Adding environmental issues to create linkages from trade to growth and then growth to environmental quality adds further complexities, and introduces a high degree of uncertainty regarding to how trade could impact the EKC relationship (see Kågeson, 1998 for further discussion on EKC).

As for the direct channels through which trade liberalization affects the environment, the traditional approach is to conceptualize three mechanisms, namely, a scale effect, a

[9] Kuznets (1955) postulated that the relationship between income inequality and economic development is inverted U-shaped. EKC term was coined by Panayotou (1993) who developed a study for the International Labor Organization. Grossman and Krueger (1993) assessed the environmental impacts of the North American Free Trade Agreement (NAFTA). Shafik and Bandyopadhyay (1992) prepared a background paper for the World Bank (1993)'s World Development Report, 1992.

composition effect, and a technique effect (WTO, 2016)[10]. These trade-induced emissions impacts were proposed through the pioneering work of Grossman and Krueger (1991)[11], and was later expounded by Grossman and Krueger (1993), and Copeland and Taylor (1994, 1995). According to Antweiler et al. (2001) a scale effect occurs when an increase in the scale of economic activity intensifies pollution, holding both the pollution abatement techniques, and the production mix, constant. Alternatively, a technique effect arises when pollution abatement is intensified leading to declining levels of emissions, holding constant both the scale, and the composition, of economic activity. Finally, if both pollution abatement techniques, and the scale of economic activity, are held constant, but emissions rise as the composition of production shifts towards more pollution-intensive production, then a composition effect is said to arise (Antweiler et al., 2001).

Antweiler et al. (2001) theorizes the scale, composition, and technique effects by proposing a simple model that decomposition the overall effect of a change in pollution, after trade is liberalized. In their model, differences in factor endowment and income, jointly determine the trade patterns. The model builds on the idea that industries that pollute heavily are also highly capital intensive, and assume a small open economy that comprises two industries each producing one final goods, under constant returns to scale. The polluter is industry X, that is capital intensive and employs primary factor capital, K, and generates pollution per unit of production, as a by-product. Abatement technology is available for industry X, under the assumption of diminishing returns to abatement activity. Firms in industry X, aiming to maximize profits will jointly choose gross output of the dirty good X, and their respective abatement functions. The other industry (Y), produces a clean good, Y, by employing the primary factor labor, L. Finally, the economy has a government that decides on the level of the pollution tax, that is an increasing function of the economy wide optimal tax (Antweiler et al., 2001).

[10] Conceptualization of the three independent effects (scale, composition and technique) of freer trade on the environment was first applied to analyze the impact of the North American Free Trade Agreement (NAFTA) on the environment (see: "*The impact of trade opening on climate change*" (WTO, 2016).

[11] The terms trade-induced scale, and technique, effects were introduced by Managi, et al., (2009) to refer to the impact on emissions from trade opening through the scale and technique effects.

It is conjectured that because a country's comparative advantage due to its resource abundance could either be on pollution-intensive industries, or relatively cleaner production, the sign of the composition effect might be ambiguous (Kuik and Verbruggen, 2002; Managi, et al., 2009). Also, the strength of a country's environmental policy determines whether the composition effect is positive or negative. The impact on a country's level of pollution that is associated with resource abundance is called a capital–labor effect, and the one relating to the strength of environmental policy, is called an environmental regulation effect (Managi, et al., 2009).

In addition to the three direct traditional channels through which freer trade impacts environmental quality, Kreickemeier and Richter (2014) adds a fourth one, which is, a reallocation effect. On the margin, as competition intensify, efficient firms with lower emission intensities edges out of the industry those that are relatively less efficient, and have higher pollution intensities. For this reason, resources get reallocated towards efficient producers. Accordingly, the reallocation effect is the marginal decrease in overall emission intensity as productivity gains, from trade, increase. Holding the scale effect constant, the impact of trade opening on the total emissions is negative, if and only if, the level of industry-wide emission intensity falls strongly with rising productivity. Kreickemeier and Richter (2014)'s model assume that firms are heterogeneous, and they compete in monopolistically competitive goods market.

2.1.3. National borders and the environment

McAusland and Millimet (2013) modified Krugman (1980)'s model on scale economies, product differentiation, and the pattern of trade to introduce new theoretical perspectives on the linkages between trade —both *intra*national (i.e., between regions in a country) and international— and the environment. As in Krugman (1980), they assume that firms operate under monopolistic competition, and employ a constant elasticity of substitution function for product differentiation. Consumers, on their part, have Spence-Dixit-Stiglitz preferences for variety in goods. Unlike Krugman (1980), however, McAusland and Millimet (2013) have environment quality variables in their model. The model predicts that environmental quality improves, as trade intensities rise and, therefore, international trade, rather than *intra*national trade, is more beneficial to the environment. Consumers have access to a wider variety of goods and prices, thanks to international trade. This leads to welfare gains for domestic consumers. Domestic environmental regulators, however, are not concerned about pollution abroad, because of the independence that exist between environmental jurisdictions. In this regard, theorists argue that authorities in open economies have reason to ignore regulatory costs incurred abroad (see Lockwood 2001; Pflüger 2001; Haufler and Pflüger, 2004). Domestically, regulators can, therefore, set tougher environmental regulations, because pollution costs are incurred by exporting countries. In other words, as trade intensity increase, much of the consumer surplus is transferred, through exports, to importing countries, and accordingly, regulators in importing countries are less willing to sacrifice local environmental standards. This way, growth is said to have a decoupling effect (Pflüger, 2001) that predicts that regulators set inefficient emission taxes because of inducement by consumer price spillovers. The decoupling effect is one of McAusland and Millimet (2013)'s channels through which growth in a foreign economy impacts domestic environmental regulations. Other two channels that are related to access by domestic consumers of a wider variety of goods, are income and substitution effects, and which are opposing forces. On the one hand, variety-induced income effects increase the demand for stricter environmental regulation; that is, as incomes rise because of access by consumers to a wider variety of goods at competitive prices after trade, so will the demand for cleaner environments increase, ceteris paribus. Nevertheless, the demand for stricter environmental regulations might fall because of variety-induced substitution effects, with incomes held constant (McAusland and Millimet, 2013).

2.1.4. "Pollution haven" hypothesis

The *environmental Kuznets curve* (EKC) theory was concerned with the effects of trade-induced growth on the environment. Another theoretical issue that preoccupied economists was the real and perceived costs that environmental regulations themselves impose, and that could adversely undermine a country's comparative advantage. In this case, the debate focused on the fear that free trade might "induce a race to the bottom" through easing of environmental standards, as regions compete for industry and jobs (Brunnermeier and Levinson, 2004). From this reasoning, there emerged the "pollution haven" hypothesis, that hold the view that polluting industries in industrialized economies, where environmental standards are high, might relocate to developing countries, where environmental regulations are weaker, since the latter are perceived to have comparative advantages in dirty production[12]. As a result, differences in emissions across countries are attributed to varying environmental regulation and trade flows. A related, but dissimilar concept to the "pollution haven" hypothesis, is the "pollution haven" effect, that is discussed later in this thesis, and that as Taylor (2004) assert, focuses on tightening of environmental regulations to deter exports (or to stimulate imports) of dirty goods.

Copeland and Taylor (1994) formalized the "pollution haven" hypothesis in a static two countries (North, developed, and South, less developed) general equilibrium model. In this model, the North differs from South only in that the North's per capita endowment of human capital is relatively larger than that of the South. They consider the equilibrium position where country North selects a relatively higher pollution tax than country South. North, endowed in relatively higher income than the South, imposes a higher pollution tax. Given that the North-South divide is only in respect of human capital endowments, pollution becomes a relatively scarce, and consequently costly, input in the North in the autarky, no trade scenario. Consequently, country North loses comparative advantage in

[12] The simple factor endowment hypothesis, that posit that trade liberalization attracts dirty capital intensive activities to developed countries as they are relatively capital abundant, is the natural alternative to the "pollution haven" hypothesis (Antweiler, et al., 2001).

producing dirty goods and only clean industries set up production facilities there. Pollution-intensive industries prefer to migrate to the South. This is the model's basis for trade. The North and South are willing to exchange, in equivalent goods, effective labor services that are abundant in the North, with pollution services that are relatively far in excess in the South. Eventually, the gap between factor prices will close, because of excess demand for pollution services in the South. The model is highly stylized, however. It excludes many determinants of trade, other than human capital that is the only factor of production, and income differentials between North and South. However, the authors argue that their model forms a good basis of interpreting earlier empirical work. Given the human capital factor that determines demand for environmental goods and the level of environmental controls, Copeland and Taylor (1994)'s model predict that international trade serves as a conduit for dirty industries' migrations from developed, to developing countries.

Several authors, including Bommer (1999), Levinson and Taylor (2008), Benarroch and Gaisford (2014), propose theoretical explanations for or against, the "pollution havens" hypothesis, and effect. In support for the "pollution haven" hypothesis, Bommer (1999)'s simple signaling model demonstrate that trade liberalization in a domestic market where environmental standards are stringent, cause dirty goods to be relatively more import competitive. Consequently, a firm's decision to relocate production to a "pollution haven", became a strategically cheaper option. Thus, global environmental quality deteriorates, as firms in the potentially cleaner environment deter governments from imposing harsher environmental standards (Bommer, 1999). In contrast, Benarroch and Gaisford (2014) propose a multi-country model covering intra- and inter-industry trade under monopolistic competition, and that demonstrates how "pollution havens" would not arise. All countries in the model produce two goods, a differentiated product that is skill-intensive, and a homogenous one that is labor-intensive. Pollution, which is a by-product of the production process, may be abated. The model predicts a fall in pollution in all countries if the differentiated-good sector is amply cleaner, and conversely, pollution increases in all countries when the differentiated-good sector is sufficiently dirtier (Benarroch and Gaisford, 2014).

2.1.5. Choice of policy instruments

The final theoretical piece of literature that we will discuss deal with the compatibility of policy instruments that aim to tackle trade-induced pollution. An environmentalist response to the trade liberalization and environmental quality trade-offs is the implementation of effective regulatory controls that maintains the status quo on the net overall environmental impact, as economic activities expand. In this regard, the environmentalists prefer tougher standards for pollution abatement, arguing that "polluters" should pay the maximum amount for the damage they cause to the environment. Accordingly, the polluter pays principle is used to justify the use of specific instruments to abate pollution (Lloyd 1992).

The ideal pollution abatement policy, is one that directly targets emissions (see Corden & Falvey, 1985; Bragga, 1992; Kennedy, 1994; and Carraro, 1999). Economists contend that a uniform per unit of emissions tax, that is targeted to discourage emissions, is an optimal policy (Lloyd, 1992, Markusen, 1975a, and Markusen, 1975b). However, where environmental instruments are lacking or are difficult to implement because of weak institutional capacity (Bohm and Russell, 1985) —that is, in a second-best world—, then "trade policy interventions, alone or combined with environmental taxes, can be welfare improving." (Beghin, et al., 1994). In this regard, Copeland (1994) and Krutilla (1991) explain the related issues for a polluted small, and a large trading country, respectively.

WTO rules concerning product regulations, food safety, and animal and plant health, allows members to apply country specific trade-related actions to protect the environment, but such actions should not be disguised barriers to free trade. Although the WTO has no agreement on the environment, its rules relating to technical barriers to trade and sanitary and phytosanitary measures (WTO, 2016) are used by countries to justify restriction of entry of agricultural goods into domestic markets. Kirkpatrick and Scrieciu, (2008:506) refers to the European Union (EU)'s protectionist subsidies on production and exports of agricultural products as an example of the use of trade policy as an instrument for environmental control[13]. This approach was, however, discredited as inefficient by Anderson and Blackhurst (1992), in their publication titled "*The Greening of World Trade Issues*". Despite this contention, trade policy continues to be applied for environmental controls (see Blackhurst and Subramanian, 1992; and Subramanian 1992), and this, Beghin, et al., (1994:172) contend, is puzzling. From these discussions, there emerged a consensus that more research efforts were needed on coordinated trade and environment policies for abating pollution (see Copeland, 1994; Beghin, et al., 1994).

2.2. Empirical Literature

2.2.1. Econometric results

Stringency of environmental policy

In a pioneering study covering the late 1960s and early 1970s, Tobey (1990) used a cross-sectional model of international trade by Hechscher-Ohlin-Vanek (HOV), to test the hypothesis that stringency of regulations in industrialized countries had significant effect on international trade patterns in highly polluting industries. The author, however, did not find overwhelming evidence in support of his hypothesis. The conclusion that stringency of differing national environmental rules, had no effect on the world distribution of 'dirty' industries, was in stark contrast to the unsupported argument by environmental skeptics that stricter pollution abatement could have a small, but discernible adverse effect on the 'balance-of-trade' (Tobey, 1990).

Despite Tobey (1990)'s work, the debate on the *causal* impact of trade on the environment, which is one of the most important debates in trade policy (Taylor, 2004),

[13] Kirkpatrick and Scrieciu, (2008:506) argue that the challenge is how to decouple measures that protect the environment from those that are protectionist in nature.

has taken long to resolve partly because of inconsistent findings (McAusland and Millimet, 2013). Using cross-country data covering the Organization for Economic Co-operation and Development (OECD) and developing countries over 1973-2000 period, Managi, et al., (2009) employed a dynamic generalized method of moments (GMM) panel data approach to evaluate the effects of trade openness on the environment. For their indicators of pollution, they found that freer trade was associated with lower emissions in OECD countries. In developing countries, however, trade opening was found to increase substantially the emissions of sulfur dioxide (SO2), and carbon dioxide (CO2), but was associated with lower levels of biochemical oxygen demand (BOD). These results support Tobey (1990)'s conclusion, and the findings by OECD (1993) and Jaffe et al., (1995), that tougher environmental controls in developed economies do not undermine trade competitiveness.

Grossman and Krueger (1993), who also empirically examined the pioneering work by Tobey (1990), predicted that trade openness could have both positive and negative effects on the environment. On the one hand, Antweiler et al., (2001) find that freer trade is good for the environment —a finding that is supported by Dean (2002)—, and at the worst, its effects are environment-neutral. Frankel and Rose (2005), and McAusland and Millimet (2013) also support the finding that trade is associated with lower emissions. Ederington et al. (2005), and Levinson and Taylor (2008), however, find that pollution abatement costs have adverse effects on net exports, which indicate that net exports increase as pollution intensify. These inconsistent outcomes of empirical evidence have led to a huge amount of academic literature on the trade-environmental linkages, a few of which are explored next.

Environmental Kuznets curve (EKC)

Managi, et al. (2009) used econometric techniques to estimate an equation with terms for per capita gross domestic product (GDP) and its quadratic to capture both scale, and technique effects, respectively. For BOD, they found that average incomes remained negative for both the OECD and non-OECD countries (i.e., no change in sign as income levels rises). This was a rejection of the predictions of the EKC hypothesis. However, for both SO2 and CO2 emissions, average incomes were positive for non-OECD countries, and negative for OECD countries, an indication of support for the EKC hypothesis. They estimate that the average income turning point associated with this change in sign, for SO2 and CO2 emissions, was US$14,045 and US$24,732 for non-OECD countries, and US$24,616, and US$29,678, for OECD countries, respectively. The OECD countries have a relatively higher capital-labor ratio because of their comparative advantage in capital-intensive goods, and therefore, require a relatively larger average income turning point, compared to non-OECD countries, for the technique effect to offset the scale effect (Managi, et al., 2009).

A study by Torras and Boyce (1998) assessed the EKC hypothesis and found that factors such as literacy, civil liberties, and political rights were influential in addressing environmental quality in low-income countries in respect of air and water pollution. This suggests that a generalization of the prediction of the EKC hypothesis across countries is problematic because other complementary factors to income growth might play an important role in influencing environmental outcomes. The general predictions of the EKC hypothesis have also been qualified by De Bruyn, et. al., (1998) who found that emissions of carbon dioxide (CO2), nitrogen oxide (NOx), and sulfur dioxide (SO2) in selected developed economies declined because of the positive effects of growth, technological progress, and structural reforms. Shafik (1994) used a panel data of 149 countries over the 1960-1990 period to investigate the relationships between per capita incomes and environmental quality while controlling for climate, technology, and policies that influence environmental performance. The author concludes that where environmental costs are localized, and private and social benefits of abatement are substantial, countries are more likely to implement policies to stop environmental degradation that accompany growth (Shafik, 1994). Grossman and Krueger (1995) make a similar argument suggesting that the strongest link between income and the environment is induced by policies that respond to citizenry demand for measures that protect the environment.

The “pollution haven” hypothesis

The “pollution haven” hypothesis was given credence by an early study by Low and Yeats (1992), that used the United States (US) data over the 1965-1986 period, to investigate how changes in trade had impacted emissions intensities in the rest of the world. The authors concluded that developing countries have revealed comparative advantages for producing pollution-intensive commodities (Low and Yeats, 1992). Akbostanci and Türüt-Asik (2007), evaluated using a panel data approach, the role of dirty industries in Turkey's exports of manufactured goods over the period 1994–1997. They found that higher exports were associated with an increase in dirty manufacturing industries, an evidence in support of the “pollution haven” hypothesis. Feridun et al. (2006) also supported the “pollution haven” hypothesis in the case of Nigeria where trade-induced technique effect was small but negative. Cole and Elliott (2003a) used two methodologies on US inter-industry trade data, and arrived at contradicting results. From one point of view, they differed with Tobey (1990), and found support for the “pollution haven” hypothesis when they employed the ‘new’ trade model with monopolistic competition and differentiated goods. In this case, they concluded that environmental regulations had a statistically significant influence on the share of inter-industry trade. From another point of view, however, using the Heckscher-Ohlin-Vanek (HOV) model of trade they agreed with Tobey (1990)’s finding that the relationship between environmental regulations and ‘dirty’ net exports was insignificant. This appears to contradict the predictions of the “pollution haven” hypothesis (Cole and Elliott, 2003a).

Birdsall and Wheeler (1993)’s case studies and econometric evidence on Latin American countries soundly rejected the "pollution haven" hypothesis, supporting the view that there was no association between trade liberalization and higher foreign investment, on the one hand, and freer trade and pollution-intensive industrialization, on the other.

Surprisingly, the authors find that trade openness increased demand for developed countries' cleaner technologies, and this was beneficial for the environment (Birdsall and Wheeler, 1993). Jaffe et al., (1995)'s review of available evidence on the linkages between environmental regulations and trade competitiveness in manufacturing in the United States (US) found little evidence that stringent environmental regulations had a large adverse effect on competitiveness, or relocation of "pollution-intensive" industries. Their evidence, therefore, also discounted the "pollution haven" hypothesis, thus supporting the findings of earlier studies, including the one by Tobey (1990) (Jaffe et al., 1995).

Grether and De Melo (2003) who used a gravity panel model of bilateral trade flows and production for 52 countries during the 1981-1998 period in five heavily polluting industries, did not find much evidence in support of the "pollution haven" hypothesis. They found that heavy polluting industries exhibited a North-South migration pattern except for non-ferrous metals industries that migrated to the North. They argue that the delocalization movements were a response to factor-abundances, and surprisingly, not because of North-South environmental regulatory gaps (Grether and De Melo, 2003). Ederington et al. (2004), who employed the Grossman and Krueger (1993) regression approach to analyze shifts in US manufacturing toward cleaner industries over the 1972-1994 period, against industry-level data on US imports, found no evidence supporting the "pollution havens" hypothesis. They concluded that tariff changes in the US after trade liberalization did not disproportionately affect pollution-intensive industries, as there were also shifts towards cleaner production and imports (Ederington et al., 2004).

The validity of the "pollution havens" hypothesis has also been empirically investigated using foreign direct investment (FDI) flows. Broadly, there is mixed evidence in support of the assertion that weaker environmental regulations attract relatively higher FDI flows. This is what McGuire (1982) observed in the case where factors of production are freely mobile across frontiers. This conclusion is supported by Eskeland and Harrison (2003) who found weak evidence that multinationals relocate in sectors with high levels of air pollution. The authors also observed that, at best, results were ambiguous regarding the pattern of FDI in the US towards industries with high pollution abatement costs. Javorcik and Wei (2004), who used firm-level data of FDI inflows to 25 transitional economies in Eastern Europe and the former Soviet Union economies found no systematic evidence to support the assertion that dirty industries are relatively more attracted to jurisdictions with weak environmental standards. More recently, Manderson and Kneller (2012), using outward FDI by United Kingdom (UK) firms, did not find robust evidence to support the assertion that dirtier, compared to, cleaner multinationals are more likely to migrate to host countries with weak environmental policy. Rather, they found evidence that countries that offer easier access to intermediate production inputs, and that are open to international trade, are more likely to attract relatively dirtier FDI from the UK.

The weak evidence on the "pollution haven" hypothesis indicate that there are other factors, other than differences in the costs of abating emissions, that influence industry relocation decisions. These include factor endowments (Grossman and Krueger, 1993; Tobey, 1990), and political economy factors. Furthermore, trade liberalization causes trade openness to increase and induces technological change that could work against the predictions of the "pollution haven" hypothesis (Taylor, 2004). Finally, econometric methodological shortcomings that fail to control for unobserved heterogeneity, and endogeneity, could lead to the likelihood of not observing important "pollution haven" phenomena (Brunnermeier and Levinson, 2004).

The "pollution haven" effect

The failure to find support for the "pollution haven" hypothesis led to the strand of literature relating to the "pollution haven" effect. The concept of "pollution haven" effect refers to tightening of environmental standards to deter exports (or stimulate imports) of dirty goods (Taylor, 2004)[14]. Levinson and Taylor (2008) developed a theoretical model

[14] The "pollution haven" effect and the "pollution haven" hypothesis are two different, but related concepts. Recall that the "pollution haven" hypothesis relate to the concern of possible relocation of dirty industries

that they used to estimate a reduced-form equation that linked industry net imports to local and foreign markets' measures of environmental regulations, factor costs, and trade tariffs. Their panel data included indicators of United States (US) environmental regulations, and data on US trade flows with Canada and Mexico for 130 manufacturing industries from 1977 to 1986. They argue that their findings support the presence of a "pollution haven" effect, as pollution abatement (environmental regulatory) costs were associated with a negative effect on net exports. They estimated that a 1% increase in pollution abatement costs caused a 0.4%, and 0.6% increase in net imports by the US from Mexico, and Canada, respectively. These results were statistically significant (Levinson and Taylor, 2008). Ederington et al. (2005), like, Levinson and Taylor (2008) also found that pollution abatement costs have adverse effects on exports, a support for the "pollution haven" effect. Cole and Elliott (2005) who included in their study the differentials in both factor endowments and environmental regulations found that US' pollution-intensive FDI flows could be attracted to Brazil and Mexico, an evidence in support for the "pollution haven" effect. This was because Brazil and Mexico were found to have higher levels of capital endowments relative to the stringency of their environmental regulations. Similarly, Mulatu, et al., (2010)'s investigation, using data on 16 manufacturing industries from 13 European countries, found evidence in support of the "pollution haven" effect that was relatively similar in magnitude to other determinants of industry location, such as supply of skilled labor. A recent study by Sawhney and Rastogi (2015) investigated the India-US trade flows during the 1989–2006 period, and concluded that there was no evidence in support of the "pollution haven" effect in the overall manufactured trade flows, but there was some evidence in specific highly polluting industries. Reasons have been advanced as to why the support for "pollution haven" effect has been weak (Levinson and Taylor, 2008) or how, from a theoretical perspective, such an effect might not arise (Benarroch and Gaisford, 2014).

---

from developed economies, where environmental standards are stricter, to developing economies that have comparative advantages in dirty production because of weak environmental standards.

Decomposition of environmental impacts

The failure to find support for the "pollution haven" hypothesis led researchers to explain the impact of free trade on pollution by estimating the magnitude of scale, technique, and composition effects. By estimating these effects, Antweiler et al. (2001) finds that trade liberalization is good for the environment. Employing their theoretical model, and data on sulfur dioxide (SO2) concentrations by the Global Environment Monitoring Project for 43 countries during the 1971-1996 period, they estimate that when the scale of production, and accompanying income, increase by 1%, pollution rise by about 0.3% (a positive scale effect), fall by about 1.4% (negative technique effect), and lead to relatively smaller, but negative, change in pollution concentrations (negative composition effect). Consequentially, if free trade increases GDP per person by 1%, the combined net effect reduces concentrations of sulfur dioxide by about 1% (Antweiler et al., 2001). Frankel and Rose (2005)'s findings support those of Antweiler et al. (2001). Using cross-sectional data on 41 countries in 1990, and after accounting for endogeneity of trade through instrumental variables, they found that freer trade lowers air pollution in the case of concentrations of SO2, and to a lesser extent, nitrogen dioxide (NO2). They conclude that despite their mixed results, freer trade was harmless to the environment (Frankel and Rose, 2005).

Cole and Elliott (2003b), aimed to validate Antweiler et al. (2001)'s findings by decomposing pollution into an overall effect combining scale and technique effects. They also distinguish direct composition effect (the effect that emanate from shifts in the capital–labor ratio), from the trade-induced composition effect (change in gross domestic product that is related to shifts in the production of dirty goods in response to price changes). They observe a relatively smaller trade-induced composition effect, compared to the combined scale and technique effect and the direct composition effect. In the case of SO2 emissions, as in Antweiler et al. (2001), their results suggest that both environmental regulations, and shifts in the capital–labor ratio influences pollution, and that these effects tend to cancel out each other. Specifically, on sulfur dioxide (SO2) emissions, they confirm Antweiler et al. (2001)'s finding that trade liberalization was beneficial to the environment (Cole and Elliott, 2003b). However, regarding other pollutants, Cole and Elliott (2003b)'s findings are more complex, as the magnitude and signs of the combined scale and technique effect, and the trade-induced composition effect, varied across pollutants. They find weak evidence regarding the impact of freer trade on the environment in the case of carbon dioxide (CO_2) emissions, and no effect at all, in the cases of nitrogen oxide (NO_x), and biochemical oxygen demand (BOD) pollutants. Furthermore, results varied depending on base of measurement —per capita emissions or pollution intensities. On the latter, the authors find good news as pollution intensities fall with trade for all four pollutants (CO_2, SO_2, NO_x, and BOD). On the former, a 1% increase in trade-induced income reduced per capita emissions by 1.7% in the case of SO_2 emissions. They find that per capita emissions were likely to fall for BOD pollutants, but rise, for both NO_x and CO_2 pollutants as free trade intensified. The likely offsetting effects of environmental regulations, on the one hand, and capital–labor, on the other, might explain why many studies fail to find evidence in support of the "pollution haven" hypothesis (Cole and Elliott, 2003b).

Managi, et al. (2009), unlike, Cole and Elliott (2003b), aimed to derive an overall impact (negative or positive) of trade openness on emissions, using indicators for SO_2, CO_2, and BOD. The authors used both the fixed effects and a dynamic generalized method of moments (GMM) estimation techniques on a panel of a large annual dataset for OECD and developing countries over the period from 1973 to 2000. They find that trade openness intensities cause a decrease in BOD in all countries. However, in the case of SO_2 and CO_2 emissions the intensity of trade openness causes a decrease in CO_2, and SO_2 emissions in OECD countries, and an increase in non-OECD countries. Specifically, in the long-term, on average, a 1% increase in trade openness was associated with a favorable impact of −0.155% in the case of BOD in non-OECD economies. The corresponding effect on SO_2 and CO_2 emissions was an unfavorable impact of 0.920% and 0.883%, respectively. Regarding the OECD economies, the long-term impact for SO_2, CO_2, and BOD, were favorable at −2.228%, −0186%, and −0.224%, respectively.

They explain that BOD decline in non-OECD countries because of availability of low cost technologies for abating BOD that are sourced from OECD countries. Regarding the decomposition of emissions, the authors find that a negative scale-technique effect dominate a positive composition effect in OECD countries, and therefore, the short- and long-term overall effects of trade openness on emissions was negative for all pollutants. The overall results were mixed, however, in other countries. In developing countries, SO_2 and CO_2 emissions were associated with positive scale-technique and composition effects. In this case, the short- and long-term overall effects of trade openness were positive. However, for BOD, a negative scale-technique effect dominated a positive composition effect causing the overall effect of trade openness to turn negative. The authors find that long-term elasticities were distinctly larger than the short-term elasticities. They also suggest two changes through which trade impacts emissions, which are, environmental regulation effect, and capital–labor effect. They argue that the environmental regulation effect was likely to dominate the capital–labor effect (Managi, et al., 2009).

Li, Xu, and Yuan (2015) arrive at different outcomes by finding that trade openness was associated with significant negative effects on the environment in both OECD and non-OECD economies. Using the instrumental variables (IV) methodology of Frankel and Rose (2005), and data from 134 economies over the period 1961 to 2004, the authors claim that they are the first to use air visibility data to measure environmental quality. They estimate that a 1% increase in trade openness could reduce air visibility in OECD economies, and non-OECD economies, by about 0.09%, and 0.081%, respectively. The fact that this finding holds for both developed and developing countries, unlike in Managi et al. (2009)'s case where trade openness was found to reduce pollution only in OECD countries, is a new finding in the literature (Li, Xu, and Yuan, 2015).

Do national borders matter?

McAusland and Millimet (2013) use the ordinary least squares (OLS) and limited information maximum likelihood (LIML) approaches to estimate a gravity model of trade. Their aim is to investigate the impact of trade on the environment. Using international and *intra*national trade data for the US and Canada they find evidence that international trade has beneficial effects on the environment, but *intra*national trade does not. A one percent increase in international trade intensity was associated with a decrease in total pollution by 1.2% for the average US state, and by 10.1% in the average Canadian province. Conversely, *intra*national trade was found to be harmful to the environment. A one percent increase in *intra*national trade intensity caused total toxic emissions to increase by over 5.3% and 3.3% for the average US state, and Canadian province, respectively. This indicates that trade openness has positive effects on environmental quality in the case of Canada and the US. The authors inform us that it may not be possible to replicate their work in other country settings because of data constraints (McAusland and Millimet, 2013). This is a major shortcoming of adopting econometric approaches to evaluate trade-environmental relationships, especially in a developing country setting.

2.2.2. Modeling results

Computable general equilibrium (CGE) models

Country studies: Beghin, et al., (1995) employ a CGE model[15] to analyze the tradeoffs between growth and environmental policies in Mexico in the context of trade liberalization under the North American Free Trade Agreement (NAFTA). The effects of three policies on Mexican growth, sectoral allocation, and trade are considered: pollution abatement alone; trade liberalization alone; and coordinated environmental and trade

[15] The CGE model used was the Trade and Environment Equilibrium Analysis (TEQUILA2) Model that was an adaptation from the OECD Development Centre's prototype CGE model (see Beghin, et al., 1996 for a recent version of this model).

policies. Mexico's unilateral trade liberalization policy under the NAFTA was associated with a 3.2% rise in gross domestic product (GDP) and a 2.5%-4.8% rise in all major pollutants. The authors assert that coordinated policies mitigated the undesirable effects of stand-alone policies. They show that trade opening could coexist with the tightening of environmental standards. Further, they inform us that the assumed trade-offs between growth and the environment was unlikely to attenuate Mexico's economic performance significantly. High contractionary impacts were associated with the abatement of only one pollutant —the bio-accumulative toxic substances in water. The authors conclude that, under freer trade, evidence rejected the hypothesis that Mexico could specialize in dirty industries (Beghin, et al., 1995).

Dessus and Bussolo (1998) use a recursive dynamic prototype CGE model developed by the OECD[16] to analyze, quantitatively, the association between trade liberalization and emission abatement policies in Costa Rica. The authors find that full trade liberalization by the year 2010, could worsen Costa Rica's pollution levels by between 15% and 20%. This is because Costa Rica's trade-induced scale effect (due to higher output) was found to outweigh both the trade-induced composition (shift in output), and technological (use of dirtier technology) effects. Joint implementation of free trade and effluent taxes minimized this growth-environment trade-off (Dessus and Bussolo, 1998).

Beghin, et al., (2002b)'s publication presents the outcomes of a collection of empirical investigations of the interactions between growth, international trade, and the environment in seven developing economies —Chile, China, Costa Rica, Indonesia, Mexico, Morocco, and Vietnam—, using a dynamic CGE methodology by the OECD[17]. Beghin, et al., (2002b)'s presentation on Mexico and Costa Rica draw from the work by Beghin, et al., (1995), and Dessus and Bussolo, (1998), respectively, as presented above. A comparative analysis of outcomes of the Mexican case, with those for Indonesia and Costa Rica, give interesting results (see Beghin, et al., 2002b: 233-250). In the case of Mexico, no evidence was found that major environmental degradation could emanate

[16] For a recent version of this model, see: Beghin, et al., (1996).
[17] Ibid.

from trade liberalization. Simulations for Mexico revealed that with free trade, production would get less pollution-intensive because of resource allocation, and output composition changes. There was a dominant scale effect, however, that potentially could intensify emissions in many sectors, if an appropriate environmental policy to mitigate the risks of environmental damage was not implemented. It was observed that some pollutants were strongly complementary, for example, nitrogen dioxide (NO2) and sulfur dioxide (SO2). Therefore, a pollution abatement tax that targets one such pollutant reduced emissions by far more than a tax on any one of complementary effluents. This is beneficial in reducing administrative costs of pollution control.

The cases for Costa Rica and Indonesia were, however, not promising. There was a likelihood of increasing the risk of specialization in dirty industries because of significant rise in pollution intensities after trade opening. Therefore, efforts to coordinate trade liberalization and pollution abatement policies could bear higher dividends; a trade opening policy alone was associated with substantial increases in trade-induced pollution, while on the other hand, a pollution abatement policy alone, was associated with major reduction in real output. For the cases of Costa Rica and Indonesia, trade was viewed as a pathway for pollution abatement; abating pollution in domestic production could be achieved by substituting dirty inputs produced domestically, with imports of pollution-intensive commodities in production (Beghin, et al., 2002b:233-247).

Regarding the seven cases, Beghin, et al., (2002b) argue that, with the exception of China, where trade reforms were found to have a potentially damaging impact on the environment, all the other cases support a “cautionary but favorable” impression of the links between outward-oriented growth and the environment (Beghin, et al., 2002b:4). The authors observe that their findings are consistent with those by Jha, et al., (1999), Nordström and Vaughan (1999), Wheeler and Martin (1992), and Dasgupta and Wheeler (1997), who used other methodologies. The case of China aimed to assess the country’s trade liberalization and environment policies in the context of its accession to the World Trade Organization (WTO), using a 1992-2010 base trend. China’s trade opening was viewed as potentially harmful to the environment for all pollutants. To start with, China's economy was assessed as pollution-intensive because of pervasive use of fossil fuel (soft coal) energy and construction materials, which translate into a strong scale effect when a pollution abatement policy is imposed. Because of this, trade opening heightened the risk of specialization in dirty industries. Coordinating free trade and pollution abatement policies might only minimize, but not eliminate, the growth-environment trade-offs in the Chinese case (Beghin, et al., 2002b:7/8; 183/4).

Beghin, et al., (2002a) have analyzed trade liberalization reforms in Chile in the context of the country's accession to both the North American Free Trade Agreement (NAFTA), and the Mercado Común del Sur (MERCOSUR) trade bloc[18]. Chile's membership in NAFTA was found to be environmentally friendly as it diverted trade that in turn reduced the use of cheap energy inputs. The results under the MERCOSUR scenario, however, are different as pollution was found to increase because of higher use of dirtier energy inputs. Similarly, unilateral trade liberalization intensified pollution as cheaper and dirtier energy inputs became more accessible. This had an adverse impact on urban mortality and morbidity because of a substantial increase in pollutants related to SO2, and NO2, and small particulates matter, PM10. Conversely, combined implementation of unilateral trade integration and a tax on PM10 pollutants was found to be 16% more welfare enhancing than isolated unilateral trade reforms. Freer trade was associated with an intensification of pollution in the City of Santiago, but interestingly, because of a wide scope for use of economic instruments, the environmental damage concerns were manageable. Targeting a few pollutants was found to reduce emissions of pollutants with complementary relationships. Consider the case of air pollutants comprising carbon monoxide (CO), lead, nitrogen dioxide (NO2), particulate matter, PM10, sulphur dioxide (SO2), and volatile organic compounds (VOC). Environmental taxes on NO2, PM10, SO2, and VOC were found to significantly cause reductions in concentrations of lead of 6%-7%. Further, pollution taxes on either NO2, PM10, or SO2 contributed to substantial reduction in concentrations of the other two, and in addition, some reduction in CO.

[18] MERCOSUR (Spanish: Mercado Común del Sur; English: Southern Common Market) is a sub-regional bloc whose full members are Argentina, Brazil, Paraguay, Uruguay and Venezuela.

Despite these positive developments in Chilean case, there were increases in emissions of untaxed pollutants caused by substitutability among some pollutants that are associated with the composition effects (Beghin, et al., 2002a). In this regard, an increase in bio-accumulative toxic metals in water (BIOWAT), and in soil (BIOSOIL), were found to induce decreases in levels of SO2, NO2, and PM10 pollution. These results arose because of sectoral specialization in goods that are cheap to produce and that sharply intensify pollution from untaxed emissions. The authors argue that the implementation of coordinated free trade and environmental tax policies, is of outmost priority where substitutability relationships among pollutants exist. Compared to a unilateral trade liberalization policy alone, the pace of growth in total trade slackened under combined policies. Further, at the sectoral level, certain imports (e.g. fish products) that increased under a unilateral trade liberalization policy alone, increased even more under joint policies. The authors argue that, in this situation, imports became a pathway for abating emissions. In the case of Morocco, Beghin, et al., (2002b) inform us that the objective of the study was to analyze the trade, environment, and economy linkages of a proposed free trade agreement with the European union (EU). Trade liberalization was found to be pollution-intensive in both production and consumption, if no mitigating measures are taken to protect the environment. Finally, Vietnam's trade liberalization reforms were found to increase environmental damage, but the resultant trade-offs were judged as not excessive (Beghin, et al., 2002b).

Lee and Roland-Holst (1997) use a calibrated general equilibrium model to analyze trade with Japan. One of Lee and Roland-Holst (1997)'s experiments show that a combination of an effective pollution abatement instrument and trade liberalization, achieves the twin objectives of higher welfare (e.g. higher real GDP) and lower emissions. Using the SO2 emissions, the authors demonstrate that both higher welfare and lower pollution is achieved by a combined policy of full trade tariff removal, and introduction of a uniform tax that is designed to achieve a 3.2%-7.4% ex-ante pollution abatement target (Lee and Roland-Holst (1997).

O'Ryan et al. (2005) conducted simulation on Chile, using a static CGE model ―the ECOGEM-Chile model. The authors simulate the direct and indirect effects on the Chilean economy, of raising fuel taxes ―an environmental tax reform― by 100%, accompanied by trade tariff reductions. A simulation of 100% increase in fuel taxes, leads to negative outcomes on consumption, output, trade, and real GDP. At the sectoral level, major changes occur, whereby oil extraction and production, and the transport sector contract sharply, while the electricity sector that provide untaxed energy expand. Households are also adversely affected by falling wages and falling employment as firms reduce use of labor factors due to scaling down of productive activities. On the environmental front, however, the results were positive as pollution was reduced for all pollutants ―by 17% for SO2 and NO2 emissions, and by 15% for PM10 emissions. The authors then emphasize the importance of coordinating the implementation of trade and environmental policy reforms. In the joint scenario two policies are simultaneously simulated: a fuel tax, and tariff reduction. The authors demonstrate that the adverse impact of environmental reforms, such as a reduction in consumption and production, could be mitigated by compensatory reduction in trade tariffs. However, the net results will depend on the relationship between trade and energy use across sectors (O'Ryan et al., 2005).

Li, J. C. (2005) uses a standard CGE model developed by the Trade and Macroeconomics Division of the International Food Policy Research Institute (IFPRI) to investigates whether a trade-off existed between trade liberalization and environmental quality. Using Thailand's 1998 social accounting matrix (SAM), the author evaluates the impacts of three policy scenarios: an emissions tax on energy intermediate inputs and final consumer goods with an aim of cutting emissions by 20% in reference to the base scenario; a 25% trade tariff reduction; and combined trade and emissions tax. Li, J. C. (2005) conclude that there was a modest risk for Thailand to specialize in producing dirty goods unless pollution abatement measures accompany freer trade reforms. If pollution abatement and free trade policies are jointly implemented, the author finds that economic growth is not significantly weakened. Li, J. C. (2005) results confirm findings by Dessus and Bussolo (1998) and Beghin, et al., (1995).

Although some of the studies outlined above indicate that trade openness could lead to significant rise in harmful emissions, other studies suggest otherwise. Kang and Kim (2004) conducted a study on the relationship between trade policy reforms and the environment using the Global Trade Analysis Project (GTAP) CGE model[19]. The authors found that the full removal of trade barriers between South Korea and Japan had favorable effects of reducing the overall air pollution emission by 0.36% (Kang and Kim, 2004). A more recent study by Gumilang, et al. (2011) applied the GTAP's static CGE model to analyze the environmental impacts of Indonesian's tariff reforms towards year 2022 under agreements with Japan and the Association of Southeast Asian Nations (ASEAN). The results were mixed; while CO2 emissions increased by 0.47% compared to the base scenario, the impact on water pollution was negative. The authors conclude that the impact of deepening Indonesia's trade liberalization on the environment was insignificant.

Global and regional studies: A comprehensive study on developing countries was undertaken by Eickhout et al., (2004), using both GTAP CGE model and the Integrated Model to Assess the Global Environment (IMAGE, 2001; Alcamo et al., 1998). The main goal of the study was to quantify the effect of trade liberalization on the environment. Across the regions covered, the authors found mixed evidence of the impact of trade liberalization on the environment, in the context of the Doha Round of trade negotiations. The authors argue that trade liberalization and environmental actions need to be coordinated to minimize risk of environmental damage (Eickhout et al., 2004). These findings are in line with those by Strutt and Anderson (2000) who employed the GTAP CGE model to evaluate the effects of tariff reductions on Indonesia in the context of the Uruguay Round (towards the year 2010) and the Asia Pacific Economic Co-operation's trade agreement (towards the year 2020). The authors found that trade policy reforms

[19] See Hertel (1997). *Global Trade Analysis: Modeling and Applications*, T.W. Hertel (ed.), published in 1997 by Cambridge University Press (https://www.gtap.agecon.purdue.edu/products/gtap_book.asp)

were beneficial to the environment in respect of air and water emissions and that the reforms mitigated the depletion of natural resources that are abundant in Indonesia. They concluded that at the worst, trade reforms might only cause minimal environmental degradation (Strutt and Anderson, 2000).

Using the GTAP model, Mukhopadhyay and Thomassin (2010) comprehensively assesses the environmental effects to year 2020 of the ASEAN region + 3 (China, Japan and Korea) free trade agreement. Air pollution effects (particularly, CO2) of trade liberalization were judged to be fairly large in the case of Vietnam, Indonesia and Thailand, but relatively smaller in the cases of China, Japan and South Korea. Vietnam, for example, was judged to the main beneficiary of higher growth in output in a free trade ASEAN region, and at the same time, the related impact on its environment was likely to be unfavorable. Broadly, the impact of the ASEAN + 3 free trade agreement on the environment was mixed. The authors observe that evidence, for or against, the “pollution haven” hypothesis was also mixed. This is because both developing and developed East and South Asian countries were equally likely to experience a negative or positive CO2 trade-induced composition effect depending on the selected trade liberalization scenario. The analysis of total pollution change highlighted that activity changes played a major role in driving pollution. Regarding greenhouse gas (GHG) emissions, while the effect of technology on pollution was negative in Japan, South Korea, and Singapore, they varied in the other countries included in the study (Mukhopadhyay and Thomassin, 2010).

Other equilibrium models

Multisector models: Using a multisector, multiregion applied general equilibrium model (GTAP-E), Kuik and Verbruggen (2002) analyzed the impact of unilateral implementation by the North of the Kyoto Protocol on carbon leakage in the context of full implementation of import tariffs reductions proposed under the Uruguay Round. Regarding the South, they found a positive scale effect (+11.7 Mt C02 emissions), a positive technique effect (+90.6 Mt C02 emissions), and a negative composition effect (-

22.17 Mt C02 emissions). The Uruguay Round of tariff reductions enhanced the competitive advantage of the North's CO2-intensive industries, in comparison to a scenario base of CO2 reductions without free trade. Evidence did not support that tariff reduction would induce relocation of industries to the South (Kuik and Verbruggen, 2002).

Input-output analysis: In reference to the Heckscher–Ohlin (HO) theory, and using an input-output analysis, Dietzenbacher, and Mukhopadhyay (2007) examined whether India (a developing economy), could be regarded as a pollution haven. The authors compared India's extra emissions of CO2, SO2 and NOx that correspond to 1 billion rupees of additional exports with a reduction in emissions arising from an increase of the same value of extra imports. The authors found that between 1996/1997 and 1991/1992, India moved away from being a pollution haven, and at the same time benefited highly from trade (Dietzenbacher, and Mukhopadhyay, 2007).

Partial equilibrium models: Saunders and Wreford (2005) use a partial equilibrium model to assess the impact of trade liberalization on agricultural production and greenhouse gas (GHG) emissions. The authors find that New Zealand's dairy sector returns increase with full trade liberalization with the OECD economies. A GHG emission abatement strategy without accompanying trade liberalization had adverse effects on producer returns, while trade liberalization without an accompanying emission mitigation strategy was likely to increase returns at the expense of higher GHG emissions (Saunders and Wreford, 2005). Saunders and Cagatay (2004) use a partial equilibrium model to investigate cross country linkages between trade liberalization policies, dairy production systems, and groundwater nitrate levels in developed economies. Trade liberalization was found to have an adverse effect on the European Union (EU) dairy production, but it reduced EU nitrate emissions marginally. Dairy production rose in other developed countries, accompanied by a marginal rise in emissions (Saunders and Cagatay, 2004). Gallagher and Ackerman (2000), developed a simple, partial equilibrium framework for analyzing the effect of trade policy changes on the relative concentrations of “clean” and “dirty” industries in two countries or regions in the context of the “pollution haven” hypothesis. An application of this model by Gallagher (1999) suggest that NAFTA did not significantly affect the location of “clean” or “dirty” industry in the US versus Mexico (Gallagher and Ackerman, 2000).

Table 2-1, while not exhaustive, outlines the models examined during this literature review. Empirical literature on the linkages between trade and environment quality have followed two strands of methodologies. Studies have used econometric techniques to fit regressions to estimate the impact of trade liberalization on the environment. However, there are only a few of such studies on developing countries because of lack of quality environmental indicators to support cross-country empirical analysis.

Conversely, computable general equilibrium (CGE) models that emerged in the early 1970’s (Shoven, et al., 1972), have become important tools for analyzing economic effect of policy changes in developed countries. CGE models were popularized for developing countries’ contexts by the World Bank through its pioneering project that developed the theoretical foundations of CGE models for open developing economies (Dervis, et al., 1982). CGE models are very popular in analyzing the impact of policy changes in a wide range of economic contexts (see Dixon and Jorgenson, 2013). The book edited by Batabyal and Nijkamp (2010) on research tools in natural resources and environmental economics informs us that CGE models have several advantages. These include their utility for measuring the impacts of policy shocks in a theoretically consistent manner, and for quantifying changes in the economy. The CGE models’ ability to capture indirect effects of policy shocks that are at times difficult to quantify otherwise, make the models popular with researchers who aim to assess economy wide inter-linkages between markets (factor and goods) and institutions (households, public and private sectors, and the rest of the world). As Table 2-1 illustrate, far more studies relating to developing countries have employed the CGE modeling approach, to investigate the policy trade-offs in the trade liberalization and environment nexus.

2.3. Methodological Choices

Table 2-1: **Methodological Approaches - Trade Liberalization-Environmental Linkages**

Author(s)	Key aim of study	Country/region (time-frame)	Methodology	Impact on environment
		Econometric Techniques		
Sawhney et al., (2015)	Test of "pollution haven" effect	US-India (1989–2006)	Regression analysis	Mixed evidence on "pollution haven" effect
Li, Xu, et. al., (2015)	Effects of free trade on environment	134 countries (1961–2004)	Instrumental Variables (IV)	Reduction of air visibility with trade openness
McAusland et. al., (2013)	Impact of national borders on environment	US and Canada (1997 and 2002)	Gravity model estimate	Unlike *intra*national trade, international trade is associated with lower emissions
Chang (2012)	Examine openness-environment linkages	China (1981–2008)	Vector autoregression	Mixed results for both exports and imports
Managi, et al. (2009)	Impact of trade openness on environmental quality	OECD & other countries (1973-2000)	Generalized method of moments/panel	Non-OECD (SO2 & CO2 increase; BOD decrease); OECD economies (all decrease). EKC hypothesis supported in cases of SO2 & CO2, but not BOD
Levinson et al., (2008)	Effect of environmental regulations on trade	US trade with Canada, Mexico (1977/86)	Panel data and two stage least squares (2SLS)	Increase in US abatement costs caused increase in net imports
Feridun et al. (2006)	Freer trade and pollution linkages	Nigeria (1980/1992-1999/2000)	Ordinary least squares (OLS) and generalized least squares (GLS)	"Pollution haven" hypothesis supported
Frankel et. al., (2005)	Trade-environment effects for given levels of GDP	Cross-section of 41 countries (1990)	Gravity model estimation with IVs	Trade lowers pollution concentrations
Ederington et al. (2004)	Free trade & dirty industries' migration	US (1972 -1994)	Grossman and Krueger (1993) regression approach	"Pollution haven" hypothesis not supported
Cole et al., (2003b)	Decompose pollution into an overall (scale & technique) effect. Introduces capital–labor endowments	Cross-country (1975–1990/1995)	Fixed effects and random effects panel, with two models: 'new' trade, and Heckscher-Ohlin-Vanek (HOV)	Supported "pollution haven" hypothesis under 'new' trade model, but not under HOV model. Technique effects dominate in some cases, and scale effects in others
Antweiler, et al, (2001)	Estimate of scale, technique, and composition effects	44 countries (1971-1996)	Regressions analysis	SO2 concentrations fall as freer trade raise GDP per person
Tobey (1990)	Impact of environmental policy on 'dirty' industries	World-wide (late 1960s/early 1970s)	Ordinary least squares (OLS) regressions with HOV model	Stringency of environmental policy has no significant effect on patterns of trade

(Table 2-1: **Methodological Approaches - Trade Liberalization-Environmental Linkages)** (continued)

Author(s)	Key aim of study	Country/region (time-frame)	Methodology	Impact on environment
		Applied General Equilibrium Techniques		
Gumilang, et al. (2011)	Trade liberalization-environment linkages	Indonesia (2001-2022)	Static global CGE model (GTAP)	Mixed results
Mukhopadhyay et al., (2010)	Economy wide analysis of freer trade and environment	ASEAN + China, Japan & Korea (2001-2010-2020)	Static global CGE model (GTAP)	Large impact in Vietnam, Indonesia, and Thailand.
Zhu et al., (2006)	Free trade, factor mobility, and the environment	EU, Central & Eastern European Countries (1998)	Static CGE model	Positive economic welfare effects without increases in GHG emissions
Li, J. C. (2005)	Trade liberalization and environment trade-offs	Thailand (1998 base year)	Standard CGE model (IFPRI)	Modest risk of specialization in dirty production
O'Ryan et al. (2005)	Impact of raising fuel taxes and tariff cuts	Chile (1996 base year)	Static CGE model	Positive results with environmental-trade policy coordination
Beghin et al. (2002b)	Trade liberalization through regional trade blocs and environment	Chile (1992-2010 base trend)	CGE model of trade and environment	Freer trade intensify pollution; double-dividend conjecture on joint environment and efficiency gains
Beghin et al. (2002b)	Free trade and environment given entry into WTO	China (1992-2010 base trend)	CGE model of trade and environment	For all pollutants, trade reforms harm the environment
Beghin et al. (2002b)	Analysis of growth, trade, and environment linkages	Vietnam (1995-2010 base trend)	CGE model of trade and environment	Trade reforms increases environmental damage but trade-offs are not excessive
Beghin et al. (2002b)	Trade-environment, linkages given free trade with EU	Morocco (1995-2005 base trend)	CGE model of trade and environment	Freer trade, without mitigating environmental policies is production & consumption pollution-intensive
Dessus, et al. (1998)	Trade liberalization and emission abatement	Costa Rica (1992-2010 base trend)	Recursive dynamic CGE model	Free trade might increase pollution because of comparative advantages for manufacturing
Lee et. al., (1997)	Trade, environment, and welfare impacts	Indonesia (1985 base year)	CGE model – free trade with Japan	Coordinated policies enhance welfare and lower emissions
Beghin et al. (1995)	Growth, openness, and environment links	Mexico (1990-2010 base trend)	TEQUILA2 (CGE) model	Unilateral trade liberalization increases GDP and pollution

Source: Author

2.4. Summary

Overwhelming evidence suggest that pollution intensity is higher in low-income countries compared to developed countries (Hettige, et al., 1992; Lucas, et al., 1992). However, empirical evidence on the nexus between the environment policies and competitiveness is not conclusive. Further, to paraphrase (Beghin, et al., 1994:176) “studies do not find strong evidence that environmental regulations per se have influenced competitiveness”.

Furthermore, studies have failed to support the “pollution haven” hypothesis that predicts that weak environmental regulations foster higher foreign direct investment inflows (Beghin, et al., 1994). In fact, Birdsall and Wheeler (1993)’s empirical study on Latin American countries reject the "pollution haven" hypothesis, supporting the view that there is no association between trade liberalization and higher foreign investment, on the one hand, and freer trade and pollution-intensive industrialization, on the other.

Surprisingly, the authors find that trade openness increased demand for developed countries’ cleaner technologies with beneficial effects on the environment. Dietzenbacher, and Mukhopadhyay (2007) make similar observations in the case of India, which was found to have moved away from being a pollution haven while at the same time benefiting from trade openness.

Quantitative empirical studies that have analyzed the theorized linkages between trade liberalization and environment have applied either econometric techniques, or economic modeling approaches, mainly computable general equilibrium (CGE) models. The wide variations of empirical outcomes of CGE studies on trade liberalization and environmental quality presents an opportunity to expand such studies to the African region, and Kenya, specifically.

Many subjects have been covered in studies on Kenya that use the CGE models. These include: liberalization of services (Balistreri, et al. 2015); consequences of avian flu (Thurlow, 2011); Doha Round of trade negotiations (Zepeda, et al. 2009); agriculture and income of adjustment to terms of trade shocks (Karingi and Siriwardana, 2003); impact of second oil price shock and resultant energy tax policies on the economy (Semboja, 1994); and technical efficiency changes in Agriculture (Akinboade, 1993). However, Kenya appears to have been overlooked in the literature relating to the hypothesized trade-off between trade liberalization and pollution abatement.

CHAPTER III: THE KENYAN ECONOMY

Chapter three presents Kenya's key economic, trade, and environmental indicators, and examines how these have evolved in the recent decades. It shows that the real Gross Domestic Product (GDP) growth rate has picked up over the past 5 years, a trajectory that is expected to continue in the medium term. It illustrates the trade liberalization initiatives that the country is undertaking to drive faster economic growth and industrialization. As Kenya intensifies its globalization agenda by exploiting its comparative advantages in trade, so will industrial emissions rise. These are some of the main issues that are covered in this Chapter that starts by presenting Kenya's recent economic developments, covering both the macroeconomic performance, and the structure of the economy. Next is Section 3.2 that outlines the recent developments on the international trade arena. Here issues related to Kenya's trade openness, imports, and exports transactions, and import tariffs are discussed. Thereafter, Section 3.3 provides a brief overview of the foreign direct investments flows to Kenya. Finally, before concluding in Section 3.5, Section 3.4 outlines the country's environmental policy and performance in recent years.

3.1. Recent Economic Developments

3.1.1. Macroeconomic performance

Kenya, a lower-middle income country, has the largest economy in Eastern Africa, and the 8th largest in Africa, as measured in nominal GDP[20]. The country's population was estimated at 44.23 million in 2015 (Table 3-1) which, according to the Economist Intelligence Unit (EIU) (2016) is expanding at an annual rate of 2.7%. Over the decades prior to 2009, Kenya's economy was adversely affected by political shocks that emanated from ethnic conflicts in 1992, 1997, and over the 2007-2008 period (Odero, et al., 2015),

[20] Kenya rebased its GDP in 2014 raising its per capita GDP from USD 994 to USD 1 246. The 2014 rebasing changed the base year to 2009 from 2001, updated the production, relative prices, and consumption patterns, and introduced innovations related product changes. Further, the rebasing exercise changed the utilization and acquisition of capital goods, and adopted an economic activity classification that follows international practices (Government of Kenya, 2014b).

and that caused the economy to contract significantly. Thanks to the enactment of the 2010 Constitution that introduced a more equitable economic and social order in a devolved system of 47 county governments, Kenya appears to be enjoying a period of renewed good fortune.

Table 3-1: **Kenya's Selected Economic and Social Indicators, 2009-2015**

Indicator	2009	2010	2011	2012	2013	2014	2015
Real GDP (%)/1	3.31	8.40	6.11	4.56	5.69	5.33	5.59
GDP, current prices (KSh, trillions)/1	2.86	3.17	3.73	4.26	4.73	5.36	6.05
GDP per capita (US$, Units)/1	982	1,039	1,062	1,239	1,314	1,417	1,388
Inflation, annual, consumer prices (%)/1	8.02	5.77	18.93	3.20	7.15	6.02	8.01
Exchange rate, period average (KSh per US$)/2	77.35	79.23	88.81	84.53	86.12	87.92	98.18
General government revenue (% of GDP)/1	18.79	19.80	19.46	19.15	19.76	19.93	20.22
General government total expenditure (% of GDP)/1	23.13	24.21	23.57	24.18	25.47	27.38	28.60
Total investment (% of GDP)/1	19.33	20.74	21.67	21.51	20.11	21.37	22.55
Gross national savings (% of GDP)/1	14.93	14.81	12.54	13.07	11.24	10.97	14.39
Current account balance (% of GDP)/1	-4.56	-5.92	-9.13	-8.44	-8.87	-10.40	-8.16
Trade (% of GDP/2	50.86	54.23	60.45	55.22	51.28	51.12	44.81
Exports of goods and services (% of GDP)/2	20.03	20.66	21.63	19.82	18.15	16.92	15.77
Imports of goods and services (% of GDP)/2	30.83	33.57	38.82	35.41	33.13	34.20	29.04
Tariff rate (%)/3 , /2	12.55	12.50	12.42	12.21	12.76	12.77	-
Population/1	37.70	38.50	39.50	40.70	41.80	43.00	44.23
Unemployment, total/4 , /2	9.40	9.30	9.20	9.20	9.10	9.20	-

Source: Author based on data by the International Monetary Fund (IMF) (2016) and the World Bank (2016)

Notes: /1: Source - IMF's World Economic Outlook (GDP values, in 2015, are estimates)
/2: Source - World Bank, World Development Indicators
/3: Most favored nation, simple mean, all products
/4: International Labor Organization (ILO) modelling estimate

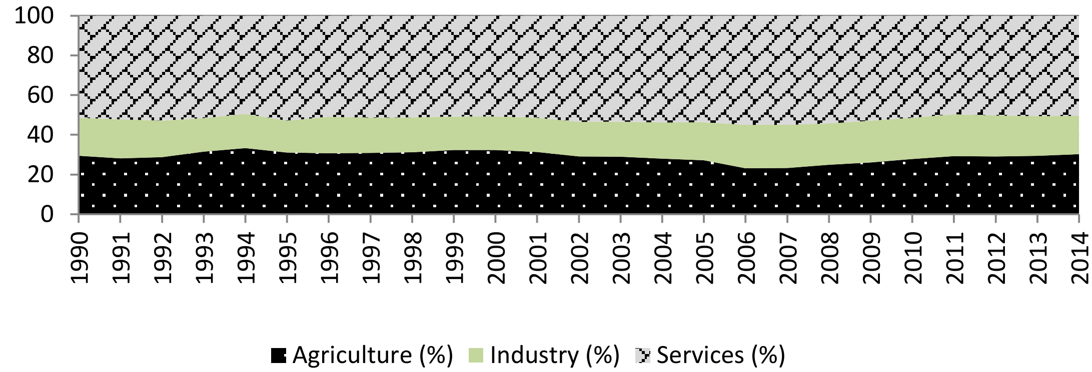
Table 3-1 show that although there are imbalances, broadly, the Kenya's recent macroeconomic performance is stable, and is improving. The real GDP growth rate reached 5.6% in 2015, up from 3.3% in 2009. This growth trajectory, per the International Monetary Fund (IMF)'s projections, is expected to continue in the medium term. GDP per capita increased by 41% from United States dollar (US$) 982 to US$ 1,388 over the 2009-2015 period. The government successfully brought down the annual inflation rate —measured in consumer prices— to a single digit of 8% in 2015, after a spike to 18.9% in 2011. Investment, as a percentage of GDP, has risen by a modest 17% between 2009 and 2015. Kenya's exchange rate regime is fully liberalized and imposes high volatility in the domestic foreign exchange market. The Kenya Shilling (KSh) per US$ period average exchange rate depreciated by 27% from KSh 77.35 in 2009 to KSh 98.18 in 2015. The fiscal deficit, as a percentage of GDP, deteriorated to 8.4% in 2015 compared to 4.3% in 2009, as the government's spending outpaced its revenue mobilization capacity. Unfavorable terms of trade shocks have caused Kenya's current account deficit to widen, as a % of GDP, from 4.6% in 2009 to 8.2% in 2015. The overall unemployment rate is 9%, and is higher among the youth. Despite structural bottlenecks that sustain relatively high interest rates, the Kenyan economy is otherwise markets driven, with prices of factors, goods, and the exchange rate, being broadly determined by forces of supply and demand.

3.1.2. Structure of the economy

Kenya's official policy has long viewed a productive agricultural sector as the foundation for industrialization (Government of Kenya, 1965). While in 1980, the shares in GDP were 32.6% for agriculture, 20.8% for industry, and 46.6% for services, a decade later the contribution to GDP had risen to 51.4% for services, while that for agriculture had fallen to 29.5%, and for industry to 19.1%. A country is classified as semi-industrialized if the composition of agriculture and services sectors' output exceed 40% (Dervis, et al., 1982:262), a threshold that is exceeded in the Kenyan case. The value added[21] in services, agriculture, and industry sectors, as a percentage of GDP, averaging 52%, 29% and 19%, respectively, over the 1990-2014 period.

[21] "Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs." (World Bank, 2016).

Chart 3-1: **Kenya's Agriculture, Industry, and Services Sectors' Shares in GDP, 1990-2014**



Source: Author based on data by World Bank (2016)

Table 3-2: **Kenya's GDP, and Sectoral Contributions to GDP, 2001-2014**

	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
GDP (billion KSh)[1]	2,138	2,148	2,212	2,314	2,445	2,588	2,766
Real GDP growth rate (%)[1]	3.98	0.48	2.95	4.64	5.67	5.85	6.85
Agriculture growth rate (%)[2]	11.66	-3.50	2.43	1.75	6.91	1.73	5.09
Agriculture (% of GDP)[2]	31.33	29.13	29.03	28.04	27.20	23.16	23.27
Industry growth rate (%)[2]	5.50	2.35	6.12	4.07	4.39	5.89	6.13
Including manufacturing growth rate (%)[2]	*0.29*	*0.08*	*5.97*	*4.46*	*4.66*	*8.21*	*4.38*
Industry (% of GDP)[2]	17.22	17.41	17.58	18.23	19.09	21.88	21.82
Including manufacturing (% of GDP)[2]	*11.00*	*11.07*	*10.92*	*11.25*	*11.82*	*14.32*	*14.46*
Services, etc. growth rate (%)[2]	-0.14	2.70	2.53	5.12	4.59	7.67	7.00
Services, etc. (% of GDP)[2]	51.45	53.46	53.40	53.73	53.71	54.97	54.92

	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**
GDP (billion KSh)[1]	2,772	2,864	3,104	3,294	3,444	3,640	3,834
Real GDP growth rate (%)[1]	0.23	3.31	8.40	6.11	4.56	5.69	5.33
Agriculture growth rate (%)[2]	-4.98	-2.30	10.06	2.35	2.95	5.25	3.46
Agriculture (% of GDP)[2]	24.92	26.14	27.83	29.27	29.09	29.42	30.27
Industry growth rate (%)[2]	-0.05	3.70	8.68	7.25	4.18	5.02	6.51
Including manufacturing growth rate (%)[2]	*1.14*	*-1.05*	*4.50*	*7.24*	*-0.56*	*5.60*	*3.41*
Industry (% of GDP)[2]	20.87	20.98	20.79	21.04	20.71	20.07	19.36
Including manufacturing (% of GDP)[2]	*13.58*	*13.39*	*12.62*	*13.08*	*12.26*	*11.93*	*11.11*
Services, etc. growth rate (%)[2]	2.74	6.23	7.30	6.09	4.73	5.41	5.79
Services, etc. (% of GDP)[2]	54.21	52.87	51.38	49.68	50.20	50.51	50.37

Source: Author based on data by the IMF and the World Bank

Notes: (1) The GDP is at constant 2009 KSh prices (IMF, 2016)
(2) These are value-added annual % growth rates (World Bank, 2016)

Chart 3-1 depicts the evolution of the sectoral distribution of GDP in key sectors of services, agriculture, and industry, during the 1990-2014 period. The dominant sectors of services and agriculture, recorded annual average growth rate of 4.1% and 2.5%, respectively, over this period. On the other hand, industrial sector grew by an annual average of 3.3% over the 1990 to 2014 period. Manufacturing sector, however, stagnated contributing only 11% to GDP in 2014, down from an average of 13.7% in the 5 years preceding 2010. The 5 years ending 2014, however, reveal a more promising picture for the industrial sector. The sector recorded the highest average annual growth of 6.3%, surpassing those for the services sector, and the agriculture sector, that averaged 5.9%, and 4.8%, respectively (see Table 3-2).

Agricultural sector

Strong growth in the agricultural sector, that averaged 4.8% per annum, over the 5 years ending 2014, pushed the sectors' GDP from KSh 669 billion in 2009 to KSh 844.7 billion in 2014. However, although the agricultural sector supports the livelihood of 80% of the population, and 65% of the country's export earnings, it is beset by institutional complexities, and low access to credit (FAPDA[22], Undated; Odero, et al., 2015). The related policy challenges have contributed to the decline of the sector's productivity, low diversification from traditional agriculture, and low commercialization of small scale farming. Consequently, the country's agriculture sector is weakly vertically integrated, with poor institutional support for agricultural exports. Regarding trade policy, Kenya, together with the other East African Community (EAC) partner states continues to restrict imports of several agricultural products (European Commission, 2015a), for example sugar, by imposing import quotas, and high tariffs. Such protectionist measures diminish the transmission mechanism of world price shocks, thus leaving the domestic supply and demand forces to largely influence the agricultural sector's growth dynamics.

[22] FAPDA stands for Food and Agriculture Policy Decision Analysis. It is a programme within the Food and Agriculture Organization of the United Nations.

Industrial sector

Table 3-3: **Real GDP in Key Sectors, 2014 and 2013**

	Share in GDP (%)	**2014 (Ksh million)**	**2013 (Ksh million)**
Mining and quarrying	0.9	35,196	30,813
(growth rate)		*(14.2%)*	*(-8.9%)*
Manufacturing	10.9	416,891	403,128
(growth rate)		*(3.4%)*	*(5.6%)*
Electricity and water supply	2.4	91,908	86,917
(growth ate)		*(5.7%)*	*(6.6%)*
Construction	4.8	185,301	163,841
(growth rate)		*(13.1%)*	*(5.8%)*
Total	19	729,296	684,699
(growth rate)		*(6.5%)*	*(5.0%)*

Source: Central Bank of Kenya (2015:6)

Recent statistics (see Table 3-3), paint a promising picture on the performance of industrial and construction sectors of the Kenya economy, whose aggregate value-added, as a percentage of GDP, stood at 6.5% up from 5%, and 3.7%, in 2013, and 2009, respectively. Data by the World Bank (2016) show that the level of industrialization in Kenya, as measured by industry value-added share of GDP, has over the past 25 years (1990-2014) been range-bound between 16% and 22%, with a spike of 21.9% in 2006. Kenya's expanding mining sector is poised for significant long-term growth given the country's major reserves of soda ash, fluorspar, and titanium oxide,[23] and the recent discoveries of recoverable oil reserves[24].

A thriving manufacturing sector typically precipitate industrialization and, therefore, it is worthwhile to look closer at the recent performance of the former. The top part of Table 3-4 gives the breakdown of the manufacturing sectors' value of output, intermediate consumption, value-added, and employee compensation at current prices over the period from 2009 to 2014. The second part of Table 3-4 presents the quantum index —an index that track the evolution of quantities of goods produced— of selected manufactures over

[23] See: http://www.oxfordbusinessgroup.com/kenya-2016/energy

[24] Kenya's recoverable oil reserves are estimated at about 600 million barrels with yet to be proven oil reserves that are projected 20.1 billion barrels. The country plans that its first oil shipments in mid-2017 to be the first oil exporter in East Africa. See: (i) http://www.energyglobal.com/pipelines/business-news/07012016/Uganda-and-Kenya-recoverable-oil-reserves-could-impact-economies-depending-on-new-export-pipeline/;
(ii) http://www.africareview.com/Business---Finance/Explorer-confirms-more-Kenya-oil-reserves/-/979184/1979246/-/4opp6e/-/index.html; and (iii) (see article by Bloomberg, "Kenya From Nowhere Plans East Africa's First Oil Exports: Energy" at: http://www.bloomberg.com/)

the same period. The quantum index cover manufactures that accounted for about 80% of the total value-added in 2013.

Table 3-4: **Manufacturing sector's selected indicators, 2009 - 2014**

Output, Intermediate Consumption, Value-Added, and Employee Compensation (Current Prices, KSh billion)						
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Value of output	770	1,259	1,581	1,620	1,738	1,822
Intermediate consumption	536	902	1,143	1,150	1,230	1,285
Value-added	235	357	438	470	508	537
Compensation of employees	75	92	98	106	127	141
Quantum Index of Production for Selected Manufactures (Base: 2009 = 100)						
	2009	**2010**	**2011**	**2012**	**2013**	**2014**
Meat products	100.0	98.1	105.1	109.2	109.4	108.8
Animal and vegetable fats/oils	100.0	103.7	101.1	98.9	111.4	118.8
Grain mill products	100.0	116.6	126.3	130.3	137.4	148.7
Other food products	100.0	122.1	116.3	113.8	129.7	133.8
Beverages	100.0	103.1	113.6	122.9	112.5	105.3
Textiles	100.0	106.2	110.4	117.7	112.1	115.2
Wearing apparel	100.0	107.7	112.8	119.0	132.7	139.1
Printing and production	100.0	100.4	100.5	100.2	102.3	99.3
Refined petroleum products	100.0	103.2	114.0	91.4	47.0	0.0
Chemical and chemical products	100.0	110.0	116.0	116.1	112.6	115.7
Rubber products	100.0	96.1	72.0	82.1	100.2	99.0
Plastic products	100.0	102.1	110.0	116.5	114.1	123.5
Other non-metallic minerals	100.0	109.9	119.3	125.3	135.1	156.1
Fabricated metals	100.0	110.6	123.1	131.7	154.3	175.1
Motor vehicle and trailers	100.0	104.9	113.1	123.3	119.3	125.9
Manufacture of furniture	100.0	108.4	150.2	164.2	183.8	208.3
Total Manufacturing	**100.0**	**109.3**	**116.3**	**119.2**	**127.5**	**133.3**

Source: Economic Survey, 2014 & 2015 (Government of Kenya, 2014b: 183/184; 2015a:195/196)

From 2009 to 2014, the output in the manufacturing sector expanded by 137% (KSh 1,052 billion). This mirrors the increase in quantities produced as reflected in the total manufacturing quantum index that rose by 33.3 points above the 2009 base value. While over the same 2009-2014 period, the value-added, and intermediate consumption in manufactures also increased significantly by 129% (KSh 302 billion), and 140% (KSh

749 billion), respectively, compensation to employees increased at a slower pace by 88% (KSh 66 billion). Manufactures of furniture, fabricated metals, and other non-metallic minerals, supported this high output growth trajectory, rising by 108.3 points, 75.1 points, and 56.1 points, above the 2009 base value, respectively. Following this is a group of manufactures comprising grain milling, wearing apparel, other food products (coffee, tea, refined salts, etc.), motor vehicle and trailers, and plastics whose expansion ranged from 23.5 to 48.7 points. Manufactures of food products normally reflect the performance of the agricultural sector. A third group that comprises the manufactures of animal and vegetable fats/oils, chemicals, and textiles achieved growth of rates of between 15.2 and 18.8 points. In 2014, the refining of crude fuel from Kenya Petroleum Refineries Limited was stopped. Output of meat products and beverages expanded by 8.8 points and 5.3 points, respectively, above the 2009 base value, while that of printing and production, and rubber products, contracted by about 1 point.

On the policy front, Ronge and Nyangito (2000) define two phases relating to Kenya's industrialization strategy: import-substitution industrialization, and export-oriented industrialization (see Table 3-5). Before the 1980s, the country's policy stances aimed to protect "infant-industries" through quantitative import controls, punitive tariffs, an overvalued exchange rate, and export subsidies. Thanks to access to a wider export market under the initial EAC customs union with Uganda, and Tanzania that was launched in 1967, but collapsed in 1977, Kenya managed to expand its industrial base over this period[25]. The collapse of the initial EAC treaty, in the backdrop of excessive market distortions that eroded Kenya's competitiveness in manufactures, however, curtailed the county's further progress towards industrialization.

Ronge and Nyangito (2000)'s second phase coincides with the push by the International Monetary Fund (IMF), and the World Bank for developing countries to implement structural adjustment programs of the 1980s. Kenya, on its part, launched its home-grown

[25] See *"The History Of The East African Community"* at: http://eacgermany.org/eac-history/. The Treaty to re-launch the EAC was signed on November 30, 1999 and was ratified by the initial member states, Kenya, Tanzania, and Uganda on July 7, 2000. Rwanda and Burundi became full members of the re-launched EAC on July 1, 2007, and South Sudan, on March 2, 2016.

reforms through the Economic Management for Renewed Growth (Sessional Paper No. 1 of 1986) aiming to liberalize trade and the exchange rates, provide exports incentives, and to privatize state enterprises. These goals faced uneven implementation leading the IMF to withdraw its financial support in 1997. In the backdrop of major macroeconomic imbalances and economic stagnation, the country issued its Industrial Transformation to the Year 2020 (Sessional Paper No. 2 of 1996) policy framework that envisaged industrialization as a pathway for rapid and sustained economic growth. In the new paradigm that was implemented under the Eighth Development Plan (1997–2001), and the Ninth Development Plan (2002–2008), the government was mandated to provide incentives and strengthen institutional frameworks for private sector led industrialization. These objectives were, however, not fully realized because of discontinuation of financial support by the IMF, and the World Bank in the decade ending 2003 (Ronge and Nyangito, 2000).

Table 3-5: **Industrial Sector Development in Kenya: A Historical Perspective**

Policy framework	**Policy instruments**
Phase I: Import-substitution industrialization (1963-1980)	
• Broadly followed the British colonial policy	• Protecting "infant-industries"
Phase II: Export-oriented industrialization (1981-2008)	
• Economic Management for Renewed Growth (Sessional Paper No. 1 of 1986) • Industrial Transformation to the Year 2020 (Sessional Paper No. 2 of 1996) • Eighth Development Plan (1997–2001) • Ninth National Development Plan (2002-2008)	• Liberalization of trade and exchange rate, provision of export incentives, and privatization • Stable macroeconomic framework, enhanced trade policy regime, infrastructural, human resource, and institutional developments • Prudent macro-economic policies to sustain growth
Phase III: Spatial-inclusive industrialization (2009 to date)	
• Kenya's Vision 2030 (2008-2030) with three pillars: Economic, Social, and Political • The 2010 Constitution of Kenya, 6 May 2010	• Fostering macroeconomic stability, while removing bottlenecks hampering expansion of industry sector • Enhancing spatial distribution of industrialization

Source: Author based on Ronge and Nyangito (2000), Kenya's Vision 2030, and 2010 Constitution

I add a third phase from 2009 that I have named, spatial-inclusive industrialization (Table 3-5). A new era for industrial take-off in Kenya began with the issuance of Kenya's

Vision 2030 (2008-2030), and the enactment of the 2010 Constitution of Kenya (6 May 2010), that repealed the 1969 Constitution. The 2010 Constitution mandates the equitable sharing of resources between national and county governments. Further, it established an equalization fund to improve access to services to marginalized communities, that is enhancing spatial distribution, and sustainability of industrialization initiatives. Also, Kenya's Vision 2030 calls for the country's transformation into a newly industrialized middle-income country by 2030, and mandates the national government to implement several enablers to accelerate industrialization including, rapid infrastructure, technology, and human resources development (Government of Kenya, 2008). Good progress has been made to implement projects envisaged in Kenya's Vision 2030 under two plans: First Medium Term Plan, 2008-2012; and Second Medium Term Plan, 2013–2017. Under infrastructural projects, for example, the Kenya-Uganda standard-gauge railway[26], and Africa's largest wind power project ―situated in a remote, marginalized northern region and that is expected to meet 17% of Kenya's power demand[27]―, are creating new opportunities that will overcome regional inequalities both in economic and spatial terms. In the 2016 World Bank's ease of doing business rating, Kenya was ranked as the highest reformer in the region, edging up 21 positions to rank 108 out of 189 economies, a demonstration that the country is creating a competitive environment for investments[28].

[26] The first phase of the railway, from Mombasa to Nairobi is nearing completion, and is expected to be commissioned in 2017 well ahead of schedule. This phase cost US$3·6 billion, of which 90% is financed by the China EximBank. Agreement with the Chinese has been signed to extend the standard gauge railway by another 120 kilometers to serve a newly launched economic development zone at Naivasha in the Rift Valley, close to Kenya's geothermal energy source. See: http://www.railwaygazette.com/ news/ infrastructure/single-view/view/standard-gauge-to-serve-naivasha.html

[27] The Lake Turkana Wind Power project is a US$690 private sector investment that is financed by a consortium of investors including the African Development Bank, and the European Investment Bank. See news article available at: http://thinkprogress.org/climate/2015/07/06/3677104/kenya-builds-africas-largest-wind-farm/

[28] See 2016 World Bank Ease of Doing Business rating for Kenya at: http://www.doingbusiness.org/ data/exploreeconomies/kenya

Service sector

After recovering from the sharp contraction during the post-election crisis from December 2007 to February 2008, Kenya's dominant services sector slowed slightly from an annual growth rate of 6.2% in 2009, to an annual average growth rate of 5.9% over the 5-year ending 2014 (Table 3-2). Activities in the services sector that contributed significantly to GDP in 2014 were: real estate (KSh 311 billion or 8%), wholesale and retail trade (KSh 294.8 billion or 8%), education (KSh 267.8 billion or 7%), transport and storage (KSh 252.5 billion or 7%), financial and insurance (KSh 229.9 billion or 6%), public administration (KSh 150 billion or 4%), and information and communication (KSh 137.8 billion or 4%). The service sector activities that achieved the highest average annual growth rate over the period 2010 to 2014, are: information and communication (13.5%), financial and insurance (8.9%), education (8.5%), wholesale and retail trade (8.1%), real estate (4.8%), and transport and storage (4.2%). Accommodation and restaurant exhibited contraction in annual growth in both 2013 (-4.6%) and 2014 (-17.2%) because of recent terrorist attacks that have heightened insecurity.

3.2. International Trade Developments

3.2.1. Trade openness

Despite failed attempts to implement trade reforms before the 1980s (see Ronge and Nyangito, 2000; Musila, et al., 2015), Kenya’s economy remained outward-oriented. Reforms that the country introduced over the 1986-1989 period, therefore, provided further impetus to openness of the economy. These include the gradual reduction of tariffs and non-tariff barriers, and bringing the local currency under a managed float exchange rate regime (1988-1989) that evolved to a free-floating exchange rate regime by 1995 (Musila, et al., 2015). Data by the World Bank (2016) support these facts showing that from 1963 to 2014 Kenya’s trade openness ratio ―total trade (sum of exports and imports of goods and services) as a percentage of GDP― averaged 58.4%, and goods merchandise trade as a percentage of GDP averaged 43.9%. More recently, during the 2001-2014 period, the degree of trade openness was lowest in 2009 (50.48%), and highest in 2005 (64.47%) as shown in Table 3-6.

Table 3-6: **Kenya's Exports, Imports, and Total Trade Ratios (%), 2001-2014**

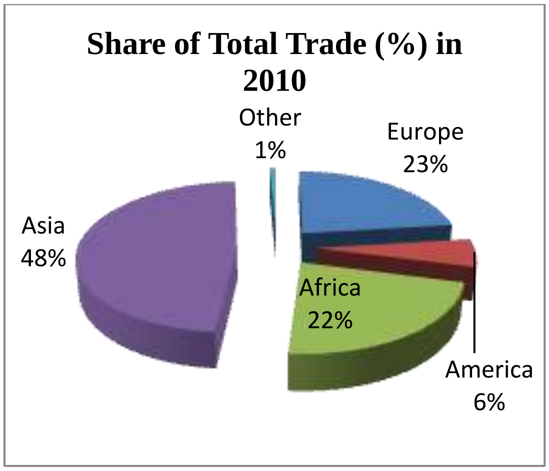
Year	Exports/ GDP	Imports/ GDP	Degree of Openness	Year	Exports/ GDP	Imports/ GDP	Degree of Openness
2001	23.19	31.18	54.37	**2008**	23.10	34.99	58.09
2002	24.46	29.41	53.87	**2009**	19.95	30.53	50.48
2003	24.22	28.58	52.80	**2010**	22.46	33.83	56.29
2004	26.61	32.87	59.47	**2011**	23.61	38.97	62.58
2005	28.51	35.96	64.47	**2012**	21.87	35.55	57.42
2006	23.02	31.64	54.66	**2013**	19.62	33.58	53.20
2007	22.10	31.48	53.58	**2014**	18.23	33.71	51.94

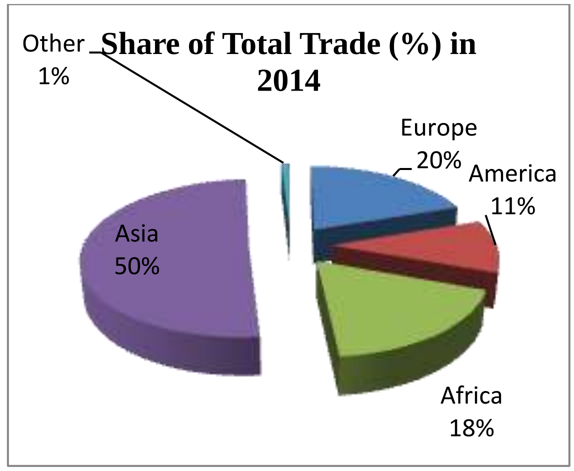
Source: Author based on trade data by United Nations (UN) Comtrade (2016) and GDP data by World Bank (2016)

3.2.2. Trade flows

Table 3-6 shows that over the 2001-2014 period, Kenya’s exports of goods and services, as a percentage of GDP, spiked to 28.51% in 2005, and declined to their lowest level of 18.23% in 2014. Over the same period, as a percentage of GDP, imports declined to their lowest level of 28.58%, in 2003 and spiked in 2011 to 38.97%. In value terms, Kenya’s exports expanded by Ksh 138 billion (43%) to KSh 461 billion between 2009 and 2014, while imports increased at a faster pace, by KSh 830 billion (105%) to KSh 1,618 over the same period (see Table 3-7 and Table 3-8). Kenya's deteriorating terms of trade mirror the depreciating of its currency. The KSh per US$, period average exchange rate, declined sharply from KSh 7.42 in 1980 to KSh 77.35 in 2009, and KSh 87.92 in 2014 (Table 3-1; World Bank, 2016). Although the currency depreciation has adversely affected imports, a positive response from the exports side has been slow. Consequently, Kenya's current account deficit widened from 4.3% of GDP in 1990 to 10.4% in 2014 (IMF, 2016).

Chart 3-2: **Kenya’s Trade Structure, 2010 and 2014**





Source: Author based on data by Central Bank of Kenya (2015)

As shown in Chart 3-2, data by the Central Bank of Kenya (2015) reveal that about 50% of Kenya’s international trade in 2014 was with Asian region. This trade grew by a compound annual growth rate (CAGR) of 13.8% to reach KSh 1,090 billion in 2014, from KSh 650 billion in 2010. European and African regions follow closely with trade flows shares of about 20% (KSh 425 billion) and 18% (KSh 388 billion), respectively, in 2014. This trade expanded at CAGRs of 7.9%, and 8.7%, respectively, over the 2010-2014 period. Finally, trade with the America region was low at KSh 233 billion in 2014, but grew fastest at a CAGR of 51.8% between 2010 and 2014.

Table 3-7, and Table 3-8, presents Kenya’s exports and imports over the period 2009-2014, respectively. Over this period, three economic categories **—**food and beverages, other consumer goods, and industrial supplies (non-food)**—** accounted for roughly 95% of Kenya's annual export flows (Table 3-7). While food and beverages, and industrial supplies (non-food), remained flat in their contribution to exports, other consumer goods, have expanded their contributions, rising from 23.4% in 2011 to 27.9 in 2014. Kenya’s imports were clustered in four economic categories, namely, industrial supplies (non-food), fuel and lubricants, machinery and other capital equipment, and transport equipment, taking up about 84% of annual import flows during the 2010-2014 period (Table 3-8). Imports of industrial supplies (non-food), machinery and other capital equipment, and fuel and lubricants, have remained roughly constant over the 2009 to 2014 period, while imports of transport equipment are growing, albeit slowly and unevenly.

Table 3-7: **Kenya's Export Values and Shares, 2009-2014**

	2009	2010	2011	2012	2013	2014
Total Export Value (KSh Billions)	**323**	**385**	**484**	**480**	**456**	**461**
Broad Economic Category						
Food and beverages (%)	42.26	44.12	40.36	41.17	42.81	40.84
Industrial supplies (non-food) (%)	26.99	28.07	30.26	29.61	27.69	27.02
Fuel and lubricants (%)	1.41	1.93	2.07	0.84	0.35	0.71
Machinery and other capital equipment (%)	2.10	2.34	2.31	2.86	2.14	1.63
Transport equipment (%)	1.80	1.71	1.56	1.64	1.78	1.57
Consumer goods (others) (%)	25.43	21.80	23.42	23.74	24.92	27.89
Other goods (%)	0.01	0.03	0.02	0.14	0.31	0.34
Total Export Shares (%)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Government of Kenya (2014b, 2015b)

Table 3-8: **Kenya's Import Values and Shares, 2009-2014**

	2009	2010	2011	2012	2013	2014
Total Import Value (KSh Billions)	**788**	**947**	**1,301**	**1,375**	**1,413**	**1,618**
Broad Economic Category						
Food and beverages (%)	11.48	7.44	8.15	7.94	7.19	6.91
Industrial supplies (non-food) (%)	29.45	31.60	31.21	29.63	31.87	28.56
Fuel and lubricants (%)	21.00	22.09	26.90	24.50	23.09	21.43
Machinery and other capital equipment (%)	17.42	18.71	16.15	18.43	17.75	17.22
Transport equipment (%)	13.13	12.34	9.98	11.85	11.38	17.22
Consumer goods (others) (%)	7.32	7.49	7.16	6.98	6.81	7.02
Other goods (%)	0.20	0.33	0.45	0.67	1.91	1.64
Total Import Shares (%)	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

Source: Government of Kenya (2014b, 2015b)

The analysis of Kenya's trade with the rest of the world highlights important stylized facts. Like other developing countries, primary and labor-intensive goods dominate Kenya's exports flows, while its imports are mainly capital-intensive goods and fossil fuels based petroleum products. The latter is bound to change once the country starts producing crude petroleum fuel from its recently discovered oil reserves[29]. The main destination for Kenya's primary commodity exports, mainly horticulture, tea, and coffee, is the European Union, while the destination for its manufactured goods is mainly to other African countries (EAC and COMESA members) and the United States in respect of apparels under the African Growth and Opportunity Act (AGOA) framework. Kenya imports capital-intensive goods and consumer goods mainly from Asian countries (India and China), and crude petroleum fuel from the Gulf countries. The economic structure of exports and import categories show trends that have not changed over the past decades, and are expected to continue in the medium term.

3.2.3. Import tariffs

Kenya's most favored nation, simple mean, tariff rate for all products averaged 12.5% during the 2009-2014 (Table 3-1; World Bank, 2016). Nevertheless, tariff rates on individual product classifications vary. In this regard, as a founding member of the EAC and the COMESA free trade blocs[30], that launched their customs unions in March 2004 and June 2009 respectively, Kenya is obliged to apply a Common External Tariff on imports from outside the EAC and the COMESA countries. The COMESA's Common External Tariff is harmonized to that of the EAC (COMESA, 2015d)[31]. The EAC Common External Tariff tariffs are set at 0% for raw materials and capital goods, 10% for intermediated inputs, and 25% for finished goods. However, there are sensitive

[29] Kenya is building a 960 MW coal-fired power plant in its coastal city of Lamu (Kant, et al., 2014). Processing and exports of recently discovered crude petroleum is planned to commence in mid-2017 (see article by Bloomberg, "Kenya From Nowhere Plans East Africa's First Oil Exports: Energy" at: http://www.bloomberg.com/).

[30] The Protocol for the establishment of the EAC Customs Union ―the entry point into the EAC trading block― was signed in 2004 (See: http://www.eac.int/customs/index.php?option=com_content&id=100&Itemid=49), and came into effect on October 31, 2009. COMESA, established in 1994, evolved from the Preferential Trade Area (PTA) that was launched in 1981. Its Treaty was signed in 1993 and ratified a year later. Currently, the COMESA region cover twenty countries ―Burundi, Comoros, Congo (DRC), Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Seychelles, Sudan, South Sudan, Swaziland, Uganda, Zambia, and Zimbabwe. To boost trade among member countries, COMESA launched its customs union in June 2009 (COMESA, 2015a, b).

[31] The overlaps between the EAC and COMESA might be eliminated in the medium-term if the June 2015 Sharm El Sheikh (Egypt) declaration by 24 African countries to launch a Tripartite Free Trade Area (TFTA) covering the COMESA, the EAC, and the Southern African Development Community (SADC) is actioned (see COMESA, 2015c).

sectors that are sheltered from external competition, with tariff rates ranging from 35% to 100%. The products categorized as sensitive include dairy, cereals, sugar, textiles and clothing.

Kenya, in September 2016, signed the European Union/East African Community Framework Economic Partnership Agreement (FEPA) that was initiated in 2007. This agreement is expected to offer EAC member states with quota free and duty free access to the European Union (EU) market. Under this treaty, Kenya is required to progressively liberalize 82.5% of its imports from the EU within 15 years, while having duty free access to the EU market from the start. Under the existing EU-EAC trade agreement, raw materials and capital goods from the EU (about 65.4% of the trade) are imported into Kenya at zero tariff, and consequently, the effective extra trade liberalization is about 17.2% of goods imported from EU, of which about 15.2% are intermediate inputs that are currently taxed at a 10% tariff rate (European Commission, 2015a, 2015b).

3.3. Foreign Direct Investments

A country's outward orientation is also measured by foreign direct investment (FDI) flows. The net inflows of FDI[32] to Kenya grew from US$ 116.26 million (0.31% of GDP) in 2009 to US$ 1,437 million (2.27% of GDP) in 2015 (World Bank, 2016). The stock of FDI increased by 26.1%, from KSh 366.8 billion in 2009 to KSh 462.5 billion in 2011 (Government of Kenya, 2014b). Over this period, the manufacturing sector received the highest proportion of FDI inflows, followed by the financial and insurance sectors. Other major sectoral recipients of FDI were electricity, gas, steam, and air conditioning (Government of Kenya, 2014b).

The EU is a source of major investment to Kenya, taking up about 44% of the total liability stocks in 2011, with the United Kingdom leading with 27% of total liabilities in 2011, while other sources included the Netherlands, France, and Belgium. The Asian

[32] FDI net inflows, according to the World Bank (2016), represent acquisition by a foreign investor of a lasting management interest of 10 percent or more of voting stock in an enterprise operating in an economy.

countries (e.g. Japan, China, and India), and the United States are other major sources of FDI (Government of Kenya, 2014b). Kenya, however, does not have a clear policy for promoting FDI to specific sectors. In the medium term, the recent finds of mineral wealth such as oil and coal could drive the next phase of sectoral allocation of FDI, but this may not affect substantially the existing trading patterns.

3.4. Environmental Developments

3.4.1. Environmental performance

Data by the World Bank (2016) show that the proportion of the Kenyan population exposed to PM2.5 air pollution[33] levels that exceed the World Health Organization (WHO)'s guideline value, increased from 43.9% in 1990 to 59.8% in 2013. This is as PM2.5 air pollution rose by 9% between 2000, and 2011. Over the same period, emissions of nitrous oxide (NO2) increased by 24%, and those of methane (CH4) by 25%. Interestingly, while the emissions from carbon dioxide (CO2) increased by 30%, the CO2 emissions from fossil fuel consumption increased by a whopping 340% (see Table 3-9).

Table 3-9: **Environmental Status in Kenya**

	2000	2005	2009	2010	2011
CO2 emissions (kt) *(Note 1)*	10,418	8,562	12,350	12,420	13,568
CO2 emissions from solid fuel consumption (% of total)	1.69	3.90	2.97	5.05	7.43
Other GHG emissions, HFC, PFC and SF6 *(Note 1)* (thousand metric tons of CO2 equivalent)	5,032	2,142	1,398	1,409	1,409
Combustible renewables and waste (% of total energy)	78.19	77.69	74.13	72.85	73.20
Methane (CH4) emissions (kt of CO2 equivalent)	22,283	25,615	27,437	27,477	27,752
Nitrous oxide emissions (thousand metric tons of CO2 equivalent)	9,248	10,595	12,012	11,363	11,477
PM2.5 air pollution, mean annual exposure					

[33] Particulate matter (PM) —also known as particle pollution—, comprise of tiny pieces of solids or liquids that are found in the air, and if less than 2.5 micrometers, are harmful to human health when inhaled.

(micrograms per cubic meter)	10.04	10.70	-	10.72	10.94

Source: World Bank (2016)

Note 1: Abbreviations: **kt** for kilotonnes; **HFC** for hydrofluorocarbons; **PFC** for perfluorocarbons; and **SF6** for Sulfur hexafluoride

To fulfill its obligations as a non-Annex I party to the United Nations Framework Convention on Climate Change (UNFCCC), Kenya conducted, in 1994 and 2010, greenhouse gas (GHG) inventories[34.] Table 3-10 provide a sectoral decomposition of Kenya's total GHG emissions in 2000 and 2010, as reported to UNFCCC in 2015. This illustrates an upward trajectory in the country's total GHG emissions in CO2 equivalent (CO2e), having risen by 27%, from 54.953 CO2e million tons (MtCO2e) in 2000 to 69.576 MtCO2e in 2010. The relative contributions towards the total GHG emissions are, 52% for carbon dioxide (CO2), 29% for methane (CH4), and 19% for nitrous oxide (N2O) (Government of Kenya, 2015a).

Table 3-10: **Kenya's Total Emissions by Sector, 2000 and 2010**

	Million Tons CO2e (2000)	**Share (2000)**	**Share Excl. LULUCF (2000)**	**Million Tons CO2e (2010)**	**Share (2010)**	**Share Excl. LULUCF (2010)**
Energy	9.760	17.8%	28.4%	14.735	21.2%	30.4%
Industrial processes	0.812	1.5%	2.4%	2.210	3.2%	4.6%
Agriculture	22.539	41.0%	65.7%	29.577	42.5%	61.1%
Waste	1.205	2.2%	3.5%	1.898	2.7%	3.9%
Sub-total (excluding LULUCF)	***34.316***	***62.5%***	***100%***	***48.420***	***69.6%***	***100%***
Land use, land-use change and forestry (LULUCF)	20.637	37.6%		21.156	30.4%	
Total	**54.953**	**100%**		**69.576**	**100%**	

Government of Kenya (2015a)

Emissions from the agriculture sector —e.g., methane (CH4) gas— accounted for 41% (22.539 MtCO2e) of the total GHG in 2000, rising to 42.5% (29.577 MtCO2e) in 2010. Land use, land use change and forestry (LULUCF), was the second highest emitting

[34] Kenya as a non-Annex I party to the Convention is mandated to submit national communications on how it is developing an inventory of greenhouse gas (CO2, CH4 and N20), and the steps it is taking to implement the Convention to the Conference of the Parties (COP). The country has submitted two reports: on October 22, 2002 and December 11, 2015. See: http://unfccc.int/national_reports/annex_i_natcom/ submitted_natcom/items/7742.php

sector at 37.6% (20.637 MtCO2e) in 2000 and 30.4% (21.156 MtCO2e) in 2010. The energy sector was third at 17.8% (9.76 MtCO2e) and 21.2% (14.735 MtCO2e) in 2010, followed by industrial processes, and waste sector, that contributed 3.2% and 2.7% of the total GHG in 2010, respectively, as shown in Table 3-10 (Government of Kenya, 2015a).

Kenya, however, is a low emitter of GHG. In 2013, the country emitted only 11.7 million tons (MT) of CO2 from fuel combustion, compared to leading emitters like China and India, that recorded emission levels of 9,023.1 MT of CO2, and 1,868.6 MT of CO2, respectively (International Energy Agency (IEA), 2015). Despite this, the risks of environmental degradation are rising because of a growing population at 2.7% per annum, demographic shift towards urban, that is estimated at an annual rate of 4.15% over the 2015-2020 period (United Nations, Department of Economic and Social Affairs (UN ESA), 2014), and a rapid pace of economic and infrastructure developments. Kenya's own projections show that total emissions are expected to increase from 70 MtCO2e in 2010 to 138 MtCO2e by 2030 (Government of Kenya, 2015a). The top three activities that will drive this growth in emissions are electricity generation, industrial processes, and transportation. The growth of emissions from the energy and transportation sectors is projected to add 43 MtCO2eq of GHGs by 2030, compared to the situation in 2013 (Kant, et al., 2014). In this regard, during 2013, Kenya's fuel combustion emissions grew by 12.8% from the level achieved in 2012, at a far higher pace than the annual emissions growth in China (5.36%), India (4.97%), and South Africa (3.1%), according to data by IEA (2015). With respect to energy generation, new coal and natural gas resources are expected to be used to meet increasing energy demand, thus driving up emissions substantially.

3.4.2. Environmental policy

The United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro in 1992 enabled Kenya's policy makers to link sustainable development to environmental quality (Government of Kenya, 2013). This motivated Kenya to develop, in 1994, an action plan on environment, and to release, in 1999, the Sessional Paper No. 6 that demonstrated the linkages between development and environmental performance. Kenya's first legal framework on environmental issues was the Environmental Management and Coordination Act (EMCA) No. 8 of 1999. The EMCA created the National Environmental Management Authority (NEMA) under the auspice of the Ministry of Environment, Natural Resources, and Regional Development Authorities (MENRRDA) to spearhead environmental management in the country. The EMCA also established other complementary institutions ―the National Environment Council, the Public Complaints Committee, the Standards and Enforcement Review Committee, the National Environment Tribunal, the National Environment Action Plan Committees, and the County Environment Committees―, to move forward the environmental agenda in Kenya (Githaiga, C. W., 2013). Furthermore, the promulgation of a new Constitution in 2010 created a new dispensation for greener development through several provisions, for example, on citizenry rights to a clean and healthy environment as enshrined in the Bill of Rights (Government of Kenya, 2013).

Kenya issued its National Environment Policy in 2013 that provides a framework for an integrated approach to the country's natural resources management (Government of Kenya, 2013). The policy complements other actions that the country has taken to address environmental concerns. By ratifying the UNFCCC in 1994 as a non-Annex I party, Kenya committed itself to take necessary measures to mitigate the adverse impacts of climate change. As a result, the country has refocused its efforts for monitoring and reporting on GHGs more consistently since 2010. Kenya ratified the Kyoto Protocol on 25 February 2005 (UNFCCC, 1997) and has actively participated in all events of UNFCCC including the 2015 COP21 (Conference of Parties, 21st) Climate Conference in Paris. To address the risks posed by climate change, Kenya, in addition to its National Environment Policy, 2013, has also issued a National Climate Change Response Strategy (NCCRS), 2010, and a National Climate Change Action Plan (NCCAP), 2013 (Government of Kenya, 2010, 2013).

In conjunction with command and control instruments (emissions and technology standards), market based instruments (MBIs), both direct (emission fees, and marketable permits) and indirect (taxes, and subsidies), have played a role in pollution abatement in developing countries. In the case of Kenya, however, the use of MBIs is limited to taxes on use of petroleum products by consumers, and subsidies that are used to incentivize reforestation and the adoption of cleaner technologies (Di Falco, et al., 2012). The lack of clear policy intentions on the use of pollution abatement policies and weak administrative capacity of the regulators, are binding constraints on use of MBIs as effective tools for pollution abatement in Kenya.

There is a major paradox in that although the country's NCCAP envisages a low-carbon economy by 2030, on the contrary, Kenya's Vision 2030 is driving industrialization through higher utilization of fossil fuels for electricity generation (Kant, et al., 2014). Kenya is, however, gifted by having a civil society that demand higher environmental quality, building on the work of Wangari Maathai (1940-2011), the 2004 Nobel Peace Prize Laureate, who called on her fellow Kenyans, and Africans in general, "to take charge of their environment" (Green Belt Movement, 2015). But heightened civil society activism, alone, is not enough to guarantee better environmental outcomes.

The focus, therefore, needs to shift towards creating adequate capacity in NEMA to control and enforce environmental standards. NEMA is directing its attention towards ensuring that proper environmental impact assessments (EIA) are conducted for projects, and environmental audits and monitoring are enhanced. Nevertheless, as is the case in many developing countries, the implementation of environmental standards in Kenya will continue to be a challenge in the medium-term because of inadequacy of institutional capacity and resources, to ensure proper monitoring and enforcement of the strict standards, that would guarantee environmental sustainability in the backdrop of accelerating industrialization.

3.5. Summary

The Kenyan economy is dominated by agricultural activities that traditionally are associated with high chemical intensity, and emissions of methane (CH4) gas. Additionally, increased trade liberalization, to drive the country's industrialization aspirations, will increasingly transform the economy to agro-industrial manufacturing. Kenya is an attractive destination for foreign direct investments in the EAC region given its relatively well-educated workforce that provide comparative advantages in manufacturing and services. The country's industrial operations are generally, more capital-intensive, in the region. A free trade pack with the EU and the EAC member countries that Kenya has been aggressively pursuing, and that was signed in September 2016 will deepen trade with the EU. It is likely that Kenya's manufacturing sector will expand considerably in the short-term. This is in the backdrop that 17% of Kenya's exports are in energy-intensive sectors whose activities are associated with significant industrial emissions. Consequently, the proportion of industrial emissions will rise as Kenya pursues the benefits of globalization, in the contexts of further trade opening, and the planned oil production and exports starting in 2017.

This is in the backdrop of a growing population that is rising at an annual rate of 2.7%, and increased urbanization. Regarding the former, a growing population implies higher consumption of fossil fuels among other dirty goods. About the latter, estimates by UN ESA (2014) show that Kenya's average annual rate of change of the urban population stood at 4.35% during the 2005-2010 period, and is growing at an annual rate of 4.15% over the 2015-2020 period. Such a demographic shift to urban, coupled with high and rising pollution from urban transportation systems and industrial activities that are urban based, will have detrimental consequences to public health, and the overall environment condition in the short-run.

These casual observations appear to indicate that Kenya will shortly be faced with a major problem of addressing the environmental consequences of trade specialization. As the country intensifies its globalization agenda by taking advantages of its traditional comparative advantages in its natural resources, a relatively well-educated workforce, and a reasonable capital base for capital-intensive manufacturing, so will industrial emissions rise. At the same time, the population is growing moderately and is shifting from rural to urban centers, and this will intensify consumption related pollution.

If Kenya implements tough pollution abatement practices, the marginal costs of production are likely to rise significantly as pollution abatement levels rise. This in turn could adversely undermine the country's current export competitiveness. Conversely, an environmental tax on energy inputs will increase the price of goods, and if the tax is very high, this might not be politically acceptable. This suggests that a trade-off could exist between trade liberalization and environmental quality. Lower environmental quality appears to imply a trade-off in terms of higher GDP growth rates in Kenya, while economic growth itself, is partly driven by higher international trade flows. These important conclusions support the need for Kenya's policy makers to take concrete steps to mitigate the adverse effects on the environment from further free trade initiatives, while pursing outward-oriented trade policies.

CHAPTER IV: METHOD OF ANALYSIS

Understanding the linkages between trade-driven growth and environmental quality is important for evidence based policy responses in both developed and developing countries. In respect of rapidly industrializing developing countries such as Kenya, it is of uttermost urgency that policy makers have evidence based prescriptions on optimal policies that would strike the right balance between expanding trade liberalization, on the one hand, and reducing industrial pollution, on the other. Policy setting in Kenya, however, is curtailed by the scarcity of research in the domain of trade and the environment because of data constraints. A 2015 released dataset, in the form of the Social Accounting Matrix (SAM) for Kenya, 2009, is now available for use by researchers. To close gaps in the literature, this Chapter presents the static Computable General Equilibrium (CGE) Model for Kenya in GAMS (General Algebraic Modeling System) software —the KenCGE Model— that is used to analyze the links between further trade liberalization and the environmental quality in the country.

The KenCGE Model introduces new knowledge by applying the Löfgren (1993) model to a different country and economic structure, and by extending the focal area of policy analysis to the environment arena. The Löfgren (1993) model is enhanced to allow policy simulations with highly disaggregated activity and commodity accounts, where an activity can produce multiple commodities, and multiple activities can generate a commodity (see Löfgren et al., 2002). Following Elshennawy (2011), there is a separation between production (unskilled labor, capital, and land that are sector specific), and non-production (skilled labor that is sectorally mobile) factors.

This Chapter starts with Section 4.1 that presents introductory remarks related to the CGE model for Kenya. This is followed by section 4.2 that provides a complete mathematical statement for the KenCGE Model, including the model's equations. The latter cover prices, production, factors and institutions, and system constraints. The parameter requirements for the KenCGE Model's calibration are noted in Section 4.3, that also presents the SAM for Kenya, 2009. Finally, Section 4.4 concludes.

4.1. A CGE Model for Kenya – An Introduction

The KenCGE Model is adapted from the CGE models in GAMS by Löfgren (1993), and is theoretically rationalized on the CGE models for open developing economies that were advanced by the World Bank (Dervis, et al., 1982). As such, the model is founded on neoclassical assumptions of perfectly competitive products and factor markets (see Robinson, 1989; Taylor, 1990; and Robinson et al., 1999). In this regard, the Kenyan economy is market driven and therefore, the neoclassical assumptions of the model are appropriate. The KenCGE Model's prices in all sectors, by assumption, are determined under competitive supply conditions in all markets, given an optimized use of inputs. Kenya is a small player in the world's goods markets, and consequently, the United States dollar (US$) equivalent of the world prices, for both Kenyan imports and exports, are given under the "small-country" assumption.

On the production side, key assumptions include constant returns to scale, and a fixed supply of primary factors of capital and labor. Goods that are imported, and those that are produced and consumed domestically (i.e. differentiation by place of origin), are modeled through a constant elasticity of substitution (CES) function. Finally, producers differentiate between production for the domestic market and for exports, through a constant elasticity of transformation (CET) function (see Powell and Gruen, 1968).

Consumer optimization behavior determines the allocation of disposable incomes between consumption and savings. Several constraints need to be satisfied, not by individual agents (Robinson, 1989:907-908), but at a macro level, for example, the equality between supply and demand for goods and factors. Unlike other domestic institutions, a budget constraint does not bind the government. To maintain balance between government revenues and expenditures, the government deficit/saving is endogenously derived. Under the current account closure rule, the difference between foreign earning and expenditures is foreign savings, where the foreign exchange rate is exogenous. The foreign savings balances the savings-investment account.

The KenCGE Model is static. It assumes that full adjustment occurs between equilibria, through a convergence process that require the use of macro closure rules. As capital stock remains fixed in the equilibrating process, the KenCGE Model may be referred to as an "equilibrium short-run" model (see Norton and Hazell, 1986:300). The model assumes that economic agents —firms and households— optimize their actions in the markets for goods, factors, and foreign exchange, and that endogenous prices clear these markets. Being myopic, these agents base their optimization decisions on static expectations of prices and quantities. The detailed equations of the proposed KenCGE Model are presented in the following section.

4.2. Mathematical Statement for the KenCGE Model

This section presents the equations of the KenCGE Model block-by-block following the Löfgren (1993) model for Egypt in GAMS. The blocks cover prices, production, factors and institutions, and system constraints. The equations are informed by Löfgren et al., (2002) in the areas of commodity production, allocation, and output aggregation, and by Elshennawy (2011) regarding the derivation of primary factors' demands and incomes. Section 8.1. (Appendix 1) presents the definitions of the sets, the parameters, and the variables. Regarding the notational conventions, the Greek alphabet is reserved for parameters.

4.2.1. Price block equations

The price block has six equations (see Table 4-1). Equations (4.1.1), and (4.1.2), represents the domestic currency prices of Kenya's imports (p_s^m), and exports (p_s^e), respectively. These tradable-goods prices are, respectively, equated to the world prices of imports (p_s^{wm}), and exports (p_s^{we}) under the open "small-country" assumption, and adjusted for tariffs (τ_s^m), and export taxes (σ_s^e). There were no export taxes in the 2009 base year, however. The exchange rate, *r*, is used to convert the world prices in US$ equivalent to Kenya Shillings (KSh).

Table 4-1: **Price Block**

Import price:

$$p_s^m = p_s^{wm}[1 + \tau_s^m]r \qquad s \in ST \qquad (4.1.1)$$

Export price:

$$p_s^e = p_s^{we}\,[1 - \sigma_s^e]r \qquad s \in ST \qquad (4.1.2)$$

Domestic supply price:

$$p_s^q = \left[p_s^d \frac{d_s}{q_s}\right] + \left[p_s^m \frac{m_s}{q_c}\right] \Big|_{s \in ST,\ c \in C} \qquad s \in S,\ c \in C \qquad (4.1.3)$$

Domestic output price:

$$p_s^x = \left[p_s^d \frac{d_s}{x_s}\right] + \left[p_s^e \frac{e_s}{x_s}\right] \Big|_{s \in ST} \qquad s \in S \qquad (4.1.4)$$

Activity price:

$$PA_s = \sum_{c \in C} PXAC_{s\,c} \bullet \theta_{s\,c} \qquad s \in S \qquad (4.1.5)$$

Value-added price:

$$p_s^{va} = [1 - \tau_s^i]p_s^x - \sum_{s' \in S'} \iota_{s's}\, p_{s'}^q \qquad s \in S \qquad (4.1.6)$$

The next two equations are the prices of domestic supply and output. Equation (4.1.3) is the price of domestic supply (p_s^q), that is expressed as a weighted average of the domestic goods price (p_s^d), and the import price (p_s^m), where the weights are the domestic share in domestic good supply ($\frac{d_s}{q_s}$), and import share in domestic good supply ($\frac{m_s}{q_c}$), respectively. On the other hand, equation (4.1.4) expresses the domestic output price (p_s^x) as a weighted average of the domestic good price (p_s^d), and export price (p_s^e), where the weights are the domestic share of domestic output ($\frac{d_s}{x_s}$), and export share of domestic output ($\frac{e_s}{x_s}$), respectively. Domestic supply from imports, and domestic output, are modeled as a constant elasticity of substitution (CES) function. Further, domestic output consumed locally and exported follow a constant elasticity of transformation (CET) function. These two aggregations functions are linearly homogenous, and an application of Euler's Theorem, facilitate their derivation (see Löfgren, 1993:18/19).

The activity price (PA_s) is specified in equation (4.1.5) as a summation of the product of producer prices ($PXAC_{s\ c}$), and yields ($\theta_{s\ c}$). This equation allows for the possibility that an activity may produce several commodities. Finally, equation (4.1.6) defines the value-added price (p_s^{va}) as the market price of domestic output (p_s^x) after indirect taxes (τ_s^i), less the sum of the unit cost of intermediate inputs, where, $\iota_{s's}$ is the quantity of input per unit of output.

4.2.2. Production block equations

Table 4-2 is a list of the fourteen equations that form the production block. A Cobb-Douglas production function, given by equation (4.2.1), is assumed to represent the relationship between output and factor use at the sector level. Two parameters, a shift parameter in the production function (α_s^{xp}), and a share parameter for factors in sectors (β_{fs}), and one variable, the demand for factors in sectors (c_{fs}^f) enter this function. Following Elshennawy (2011:16/17) the KenCGE Model disaggregates labor (L) into production (unskilled), and nonproduction (skilled) labor, where sectorally, the former is immobile, and the latter mobile (equation 4.2.2). There are four factors of production: one sectorally mobile skilled labor (LNSP), and three sector-specific factors, namely, unskilled labor (LSP), capital (K), and land (LAND)[35].

[35] Factors that are sector-specific can only be employed in their original sectors, while those that are sectorally mobile, can be allocated to any sector. The KenSAM, 2009 defines quantities for three labor factors: skilled, semi-skilled, and unskilled. This study groups skilled and semi-skilled labor into skilled labor.

Table 4-2: **Production Block**

Domestic output:

$$x_s = \alpha_s^{xp} \prod_{f \in F} |_{(f,s) \in MFS} c_{fs}^{f\ \beta_{fs}} \qquad s \in S \qquad (4.2.1)$$

Labor disaggregation:

$$L_{LS\ s}^{f} = L_{LSP\ s}^{L\ \alpha_{LSP\ s}} L_{LSNP\ s}^{L\ \alpha_{LSNP\ s}} \qquad s \in S \qquad (4.2.2)$$

Factor demand – sector specific factors:

$$L_{LSP\ s}^{f} = \frac{p_s^{va} x_s \beta_{LS} \alpha_{LSP\ s}}{w_{LSP\ s}^{s}} \qquad f \in FS,\ s \in S,\ (f,s) \in MFS \qquad (4.2.3)$$

$$K_{k\ s}^{f} = \frac{p_s^{va} x_s \beta_{ks}}{w_{k\ s}^{s}} \qquad (4.2.3')$$

$$LAND_{LAND\ Agr}^{f} = \frac{p_s^{va} x_s \beta_{LAND\ Agr}}{w_{LAND\ Agr}^{s}} \qquad (Agr = \text{agriculture}) \qquad (4.2.3'')$$

Factor demand – sectorally mobile factors:

$$L_{LSNP\ s}^{f} = \frac{p_s^{va} x_s \beta_{LS\ s}\ \alpha_{LSNP\ s}}{w_{LSNP\ s}} \qquad f \in FM,\ s \in S \qquad (4.2.4)$$

Intermediate demand:

$$v_s = \sum_{s' \in S'} \iota_{ss'}\, x_{s'} \qquad s \in S \qquad (4.2.5)$$

Commodity production and allocation:

$$QXAC_{s\ c} = \theta_{s\ c} \bullet QA_s \qquad s \in S,\ s \in CX \qquad (4.2.6)$$

Output aggregation function:

$$x_s = \alpha_c^{s\ c} \bullet \left(\sum_{s \in S} \delta_{s\ c}^{s\ c} \bullet QXAC_{s\ c}^{-\rho_c^{s\ c}} \right)^{-\frac{1}{\rho}} \qquad c \in CX \qquad (4.2.7)$$

First-order condition for output aggregation function:

$$PXAC_{s\ c} = p_s^{x} \bullet x_s \left(\sum_{s \in S'} \delta_{s\ c}^{s\ c} \bullet QXAC_{s\ c}^{-\rho_c^{s\ c}} \right)^{-1} \bullet \delta_{s\ c}^{s\ c} \bullet QXAC_{s\ c}^{-\rho_c^{s\ c} - 1} \qquad s \in S,\ c \in CX \qquad (4.2.8)$$

Domestic supply aggregation:

$$q_s = \alpha_s^{q} \left[\delta_s m_s^{-\rho_s^{q}} + (1 - \delta_s) d_s^{-\rho_s^{q}} \right]^{\frac{-1}{\rho_s^{q}}} \qquad s \in ST \qquad (4.2.9)$$

(Table 4-2: **Production Block**) (continued)

Import demand:		
$m_s = \; d_s \left[\frac{p_s^d}{p_s^m} \frac{\delta_s}{1-\delta_s}\right]^{\frac{1}{1+\rho_s^q}}$	$s \in ST$	(4.2.10)
Domestic output transformation:		
$x_s = \alpha_s^{xt} \left[\gamma_s {e_s}^{\rho_s^x} + (4-\gamma_s){d_s}^{\rho_s^x}\right]^{\frac{1}{\rho_s^x}}$	$s \in ST$	(4.2.11)
Export supply:		
$e_s = \; d_s \left[\frac{p_s^e}{p_s^d} \frac{1-\gamma_s}{\gamma_s}\right]^{\frac{1}{\rho_s^x - 1}}$	$s \in ST$	(4.2.12)
Domestic production for nontradables:		
$x_s = \; d_s$	$s \in SN$	(4.2.13)
Domestic supply for nontradables:		
$q_s = \; d_s$	$s \in SN$	(4.2.14)

Factor demands are derived by maximizing profits subject to the Cobb-Douglas function (equation (4.2.1)). This is specified in equations (4.2.3), and (4.2.4), for sector specific factors (unskilled labor, capital, and land), and sectorally mobile factor (skilled labor), respectively. The price of factors in sectors (w_f^s), enter as a denominator on right hand side of equations (4.2.3) and (4.2.4). In equation (4.2.3) land is a specific factor in agriculture sector. Equation (4.2.5) shows that intermediate input demand (v_s) is determined through fixed input coefficients under a Leontief production technology. In KenSAM, 2009, activities can produce one or more commodities. This possibility is accounted for through equations (4.2.6), (4.2.7) and (4.2.8). Equation (4.2.7) models the aggregate domestic marketable output (x_s) as a CES function. The parameters that enter this function are a shift parameter (α_s^{sc}), a share parameter (δ_{sc}^{sc}), and an exponent ($\rho_c^{s\,c}$). The quantities of marketed output of commodities ($QXAC_{s\,c}$), also enter the CES function. These are derived in equation (4.2.6) as a product of the yields of output per unit of activity ($\theta_{s\,c}$), and the corresponding quantity of activity (QA_s). Finally, equation (4.2.8) lays out the first order condition for an optimization problem that determines the choice between commodities produced by multiple activities.

The composite good in supply domestically (q_s) is determined by an Armington constant elasticity of substitution (CES) function, where a domestically produced good (d_s), and an imported good (m_s), are assumed to be imperfect substitutes (equation (4.2.9)). For this composite supply function, α_s^q, and δ_s, are shift, and share parameters, respectively. Producers determine their import demands (m_s), by minimizing costs of a combination of domestic and imported inputs —subject to the above Armington CES function (equation (4.2.10)). On the other hand, a constant elasticity of transformation (CET) function combines domestic output for domestic market (d_s), and domestic output for exports (e_s), under the assumption of imperfect transformability (equation (4.2.11))[36]. Equation (4.2.12) shows that producers determine export supply (e_s) by maximizing sales revenue —subject the above CET function—, by allocating output between domestic and export markets[37]. Essentially, this equation expresses export supply as a function of domestic output (d_s), and the ratio of prices of exports (p_s^e) to domestic sales (p_s^d). In equations (4.2.13) and (4.2.14), domestic output (x_s), and domestic supply (q_s), respectively, are both equated to domestic use of domestic output (d_s). This is because these equations relate to nontradable goods.

4.2.3. Factor and institution block equations

The factor and institution block has nine equations as listed in Table 4-3. Incomes earned by labor, capital, and land (y_f^f), appropriately disaggregated into sector specific and sectorally mobile, are defined in equations (4.3.1) through (4.3.2) as a summation of the product of quantities demanded and prices. For sectorally mobile (nonproduction) labor

[36] Imperfect substitutability and imperfect transformability are the reverse of each other (see Armington, 1969). To get the CET function for imperfect transformability, pre-multiply, by -1, all the exponents of the CET function for imperfect substitutability. Because of the restrictions that are imposed on the parameter (ρ), the isoquant for the output transformation function are concave to the origin (see Löfgren, H., 1993:26/27).

[37] The constant elasticity of transformation between two goods is modeled by the exponent $[1/(\rho_s^x - 1)]$ (Condon et al., 1987) — see equation (4.2.12). In the limiting cases, as (ρ_s^x) approaches 1, from above, the elasticity approaches ∞, and because of perfect transformability, the cheaper good is used. Alternatively, as (ρ_s^x) approaches ∞ we have the case of perfect complementarity, and the ratio between the two goods is fixed irrespective of price changes. There is also an intermediate case where a combination of the two goods is used (see Löfgren, H., 1993:28).

factors, such income is augmented with remittances from abroad, ($\emptyset^{lw}$) expressed in domestic currency using the exchange rate, *r*. Factor incomes are transferred to institutions in fixed proportions (ψ_{if}^{f}) as expressed in equation (4.3.3). Equation (4.3.4) defines incomes of households (y_{i}^{i}), as comprising the sum of transfers from factors (t_{if}^{f}), other institutions ($t_{ii'}^{i}$), the government ($\emptyset_{i}^{ig}$), and the rest of the world ($\emptyset_{i}^{iw}$). In the KenCGE Model, households include enterprises and, therefore, the term transfers from other institutions drops out of the equation. The price index, $\overline{\pi}$ (linked to government transfers), and the US$ equivalence of remittances from abroad (later converted in domestic currency using the exchange rate), are exogenous items in equation (4.3.4). Intra-institutional transfers ($t_{ii'}^{i}$) —by domestic nongovernmental institutions to all other institutions (domestic or foreign)— occur in fixed proportions ($\psi_{ii'}^{i}$) as given by equation (4.3.5). Household consumption expenditure (e_{h}^{h}) is specified in equation (4.3.6). The totality of household income (y_{h}^{i}) is allocated to direct taxes (τ_{h}^{d}), and based on household income shares (ψ), to other institutions and savings. To comply with household budget constraint, consumption is the residual.

By assumption, households maximize a Stone–Geary utility function[38] to derive their consumption demands (CD_{sh}^{h}) as expressed in equation (4.3.7). Equation (4.3.8) defines government revenues (y^{g}) as comprising various taxes (including import tariffs) and transfers —including capital— from abroad. On the other hand, equation (4.3.9) defines government spending (e^{g}), as a sum of transfers to households ($\emptyset_{i}^{g}$) that are linked to an exogenous price index, ($\overline{\pi}$), and its own consumption expenditure, where demand for goods ($\overline{\gamma}_{s}^{q}$) is exogenous. Savings are accounted for in the savings-investment balance, as by assumption, the government is not faced with a budget constraint.

[38] The Stone–Geary utility function is named after Geary (1950), who, informed by Klein and Rubin (1947)'s work, derived a constant-utility index of the cost of living, and Stone (1954) who applied a linear expenditure system on patterns of demand in Britain. Lluch, C. (1973) following a consumer utility maximization procedure, derives an aggregate consumption function that is linked to a linear expenditure system. Li, J. C. (2005: Appendix A, 271/2) presents a derivation of private consumption demand following the Stone–Geary utility linear expenditure system.

Table 4-3: **Factor and Institution Block**

Factor income - sector specific factors:

$$y_k^f = \sum_{s \in S} w_{\mathrm{ks}}^s k_{\mathrm{ks}}^f \qquad f \in FS \qquad (4.3.1)$$

$$y_{LSP}^f = \sum_{s \in S} w_{\mathrm{LSP}}^s L_{\mathrm{LSP,\ s}}^f \qquad (4.3.1')$$

$$y_{LAND}^f = \sum_{s \in Agr} w_{\mathrm{LAND}}^{Agr} L_{\mathrm{LAND,\ Agr}}^f \qquad (4.3.1'')$$

Factor income - sectorally mobile factors:

$$y_{\mathrm{LSNP}}^f = w_{LNSP}\left[\sum_{s \in S} L_{\mathrm{LSNP,\ s}}^f\right] + r\emptyset^{\mathrm{lw}} \qquad f \in FM \qquad (4.3.2)$$

Factor transfers:

$$t_{\mathrm{if}}^{\mathrm{f}} = \psi_{\mathrm{if}}^{\mathrm{f}} y_{\mathrm{f}}^{\mathrm{f}} \ ; \qquad \sum_{i \in I} \psi_{\mathrm{if}}^{\mathrm{f}} = 1 \qquad i \in I,\ f \in F \quad (i, f) \in MIF \qquad (4.3.3)$$

Institutional income:

$$y_i^i = \sum_{f \in F} |_{(i,f) \in MIF}\ t_{\mathrm{if}}^{\mathrm{f}} + \sum_{i' \in ID} t_{\mathrm{ii'}}^{\mathrm{i}} + \bar{\pi}\,\emptyset_i^{\mathrm{ig}} + r\emptyset_i^{\mathrm{iw}} \qquad i \in ID \qquad (4.3.4)$$

Intra-institutional transfers:

$$t_{\mathrm{ii'}}^{\mathrm{i}} = \psi_{\mathrm{ii'}}^{\mathrm{i}} y_{\mathrm{i'}}^{\mathrm{i}} \qquad i \in I,\ i' \in ID \quad (i, i') \in MIID \qquad (4.3.5)$$

Household consumption expenditures:

$$e_h^h = \left[1 - \sum_{i \in I} \psi_{\mathrm{ih}}^{\mathrm{i}} - \tau_h^d - \psi_h^s\right] y_h^i \qquad h \in H \qquad (4.3.6)$$

Household consumption demand:

$$CD_{\mathrm{sh}}^{\mathrm{h}} = \frac{\psi_{\mathrm{sh}}^{\mathrm{e}} e_h^h}{p_s^q} \qquad h \in H,\ s \in S \qquad (4.3.7)$$

Government revenue:

$$y^g = \sum_{i \in ID} \tau_i^d\ y_i^i + r\emptyset_{\mathrm{gov}}^{\mathrm{iw}} + \sum_{s \in S} \tau_s^i\ p_s^x x_s + \sum_{s \in ST} \tau_s^m r\ \pi_s^{\mathrm{wm}} m_s \qquad (4.3.8)$$

Government expenditure:

$$e^g = \bar{\pi} \sum_{i \in ID} \emptyset_i^g + \sum_{s \in S} p_s^q\,\bar{\gamma}_s^q \qquad (4.3.9)$$

4.2.4. System constraint block equations

Table 4-4: **System Constraint Block**

Factor markets - sector-specific factors:

$K_{\mathrm{ks}}^{k} = \lambda_{\mathrm{ks}}^{\mathrm{s}}$	f ∈ FS, s ∈ S (f, s) ∈ MFS	(4.4.1)
$L_{\mathrm{LSP}}^{L} = \lambda_{\mathrm{LSP}}^{\mathrm{s}}$		(4.4.1′)
$L_{\mathrm{LAND}}^{Land} = \lambda_{\mathrm{LAND}}^{\mathrm{Agr}}$		(4.4.1″)

Factor markets – sectorally mobile factors:

$\sum_{s\in S} L_{\mathrm{LSNP}}^{L} = \lambda_{LSNP}$	f ∈ FM	(4.4.2)

Domestic goods markets:

$\mathrm{q_s} = \mathrm{v_s} + \sum_{\mathrm{h\in H}} \mathrm{c_{sh}^{h}} + \bar{\gamma}_{\mathrm{s}} + \bar{\iota}_{\mathrm{s}}$	s ∈ S	(4.4.3)

Current account:

$$\emptyset_{\mathrm{i}}^{\mathrm{lw}} + \sum_{\mathrm{i\in I}} \emptyset_{\mathrm{i}}^{\mathrm{iw}} + \sum_{\mathrm{s\in ST}} \mathrm{p_s^{we}}\ \mathrm{e_s} + \mathrm{s^w} = \frac{1}{\mathrm{r}}\left[\sum_{\mathrm{i\in ID}} \big|_{\mathrm{(row,\ i)\in MIID}} \mathrm{t_{row,\ i}^{i}} + \mathrm{t_{row,\ lab}^{f}}\right] + \sum_{\mathrm{s\in ST}} \pi_{\mathrm{s}}^{\mathrm{wm}}\,\mathrm{m_s} \qquad (4.4.4)$$

Savings-investment balance:

$$\sum_{\mathrm{i\in ID}} \psi_{\mathrm{i}}^{\mathrm{s}}\,\mathrm{y_i^i} + (\mathrm{y^g} - \mathrm{e^g}) + \mathrm{rs^w} = \sum_{\mathrm{s\in S}} \mathrm{p_s^q}\bar{\iota}_{\mathrm{s}} \qquad (4.4.5)$$

Price-normalization:

$$\sum_{\mathrm{s\in S}} \mathrm{p_s^q}\omega_{\mathrm{s}} = \bar{\pi} \qquad (4.4.6)$$

Table 4-4 lists the six equations of the system constraint block. The closure in the factor markets is predicated on two assumptions; one that the economy is at its full employment level, and the other, that factor prices are flexible[39]. The latter assumption fosters the equilibration of supply and demand in factor markets. Equation (4.4.1) and (4.4.2) define the demands for sector-specific factors, and sectorally mobile factors, respectively, as equal to a fixed supply of such factors, assuming flexible factor prices and full employment. The goods market equilibrium requires that domestic supply ―from Armington transformation of imported goods and domestic output― be equalized to the economy-wide demand (equation (4.4.3)). In this equation, government and investment demands are exogenous, and prices are the equilibrating variables.

Equation (4.4.4) is expressed in foreign currency. It defines the equilibrium between Kenya's foreign earnings and spending. The difference between current earning and expenditure is foreign savings, where the latter is the equilibrating variable. After incorporating fixed shares of savings by households (includes enterprises) and the government account, foreign savings, expressed in domestic currency (KSh) equilibrate total savings and investments, as shown in equation (4.4.5). By Walras' law (Walras, 1874), this equation will be dropped, and savings and investment assumed to be in equilibrium. Finally, equation (4.4.6) is the price index.

4.3. Model Calibration

4.3.1. A SAM for Kenya, 2009

Like other CGE models, the KenCGE Model builds on the economy wide circular flow of income that depicts how economic actors earn and spend their incomes. Households own factors of production, and receive income and transfers from enterprises and the government. Enterprises and the foreign sector sell goods and services, and in return receive incomes. In the KenCGE Model, however, enterprises are included in households.

---

[39] The system constraint block equations apply economy-wide, and not at an individual actor level. Closure balances in the factors and goods markets are referred to as real balances, while those in respect of savings-investment and current accounts are nominal balances.

Table 4-5: **Kenya's 2009 Basic SAM Structure**

	Activities	**Commodities**	**Factors**	**Households**	**Enterprises**	**Government**	**Savings-investment**	**Rest of world (RoW)**	**TOTAL**
Activities		Marketed production by industries							**Gross output**
Commodities	Intermediate inputs by industries			Private consumption		Government consumption	Investment	Exports	**Aggregate demand**
Factors	Value-added								**Factor income**
Households			Factor income to households	Inter-household transfers	Distributed income to households	Transfers to households		Remittances from RoW	**Household income**
Enterprises			Factor income to enterprises			Transfer to enterprises		Transfer to enterprises from RoW	**Enterprise income**
Government	Taxes less subsidies on products	Import tariffs and custom duties	Factor income to government, factor taxes	Taxes on household income	Taxes on income and wealth			Transfers to Government from RoW	**Government revenue**
Savings-investment				Household saving	Enterprise savings	Government savings		Foreign savings (capital transfers)	**Savings**
Rest of world (RoW)		Imports	Factor payments to RoW		Transfers to RoW	Government transfers to RoW			**Foreign exchange outflow**
TOTAL	**Activity**	**Supply expenditure**	**Factor expenditure**	**Household expenditure**	**Enterprise expenditure**	**Government expenditure**	**Investment expenditure**	**Foreign exchange inflow**	

Source: Author, based on Government of Kenya (2015b)

The government provides public goods and in return receives tax revenues. It also subsidizes productive activities, and make transfers to households. The Social Accounting Matrix (SAM) for Kenya, 2009 (KenSAM, 2009) that was prepared and officially released by the Kenyan statistical agency ―the Kenya National Bureau of Statistics (KNBS)― in 2015 (Government of Kenya, 2015a, 2015b)[40] replicate these complex direct and indirect linkages between diverse sectors and economic agents in the Kenya economy, and is the database that calibrates the KenCGE Model's parameters. The KenSAM, 2009 provide the baseline data representing the Kenyan economy in 2009 that is assumed to be in equilibrium. Table 4-5, explains verbally, the contents of the SAM for Kenya, 2009.

4.3.2. Dimensions of the SAM

A social accounting matrix (SAM), represents an overview of the accounts of an economy's circular flows in production, factors, domestic institutions, and the outside world (Löfgren, 1993). It is an empirical data set, that forms a crucial framework for economy-wide policy analysis work as it explicitly portrays the linkages of payments and receipts by economic agents and institutions in the system (see pioneering work by Stone, 1970; Pyatt and Round, 1979, 1985). The micro SAM for Kenya, 2009 is square, as its headings in the rows and the column are similar, with equal row and column totals. Each cell in the SAM represents an expenditure for the column account and an income for the row account.

Table 4-6, illustrates that Kenya's industrial sector is well diversified and produces a wide range of capital and consumer goods. There are several non-energy intensive manufacturing industries —food manufactures (e.g., meats, fish, fruits and vegetables, coffee, tea, and beverages), and non-food manufactures (e.g., textiles, printing, machinery, and transport equipment).

[40] **Acknowledgment:** The author would like to thank Mr. Collins M. Omondi, Director, Macroeconomics Statistics, the Kenya National Bureau of Statistics (KNBS), for providing the disaggregated Kenya's 2009 balanced micro Social Accounting Matrix (SAM) for use in this study (Government of Kenya, 2015c).

Table 4-6: **Dimensions of the SAM for Kenya, 2009**

Activities/commodities (34)	
	Agriculture (1)[/a]
	Primary energy (2)[/b]
	Energy-intensive (11)[/c]
	Non-energy intensive (17)[/d]
	Construction (1)
	Transport (1)[/e]
	Other services (1)[/f]
Factors (3)	
	Labor (unskilled and skilled)
	Capital
	Land
Institutions (3)	
	Households (including enterprises)
	Government
	Rest of the world

Source: Author

Notes:

a. The agriculture sector is an aggregation of 5 sectors are: (1) crop, (2) animal, (3) support services, (4) forestry & logging, and (5) fishing & aquaculture.

b. The 2 sectors are: (1) petroleum, and (2) electricity.

c. The 11 sectors are: (1) mining & quarrying, (2) non-metal minerals, (3) chemicals, (4) rubber & plastics, (5) water supply and sewerage, (6) leather, (7) paper, (8) pharmaceuticals, (9) wood, (10) basic chemicals, and (11) metals.

d. The 17 sectors are: (1) meat, (2) fish, (3) fruit & vegetable, (4) vegetable/animal oils & fats, (5) dairy, (6) grain, (7) bakery, (8) sugar, (9) coffee, (10) tea, (11) other food, (12) beverages, (13) tobacco, (14) textiles/clothing, (15) printing & reproduction, (16) machinery & equipment (including transport equipment), and (17) other manufactures.

e. The transport sector aggregates 6 sectors which are: (1) railways, (2) passenger road, (3) freight road (4) pipeline, (water), and (6) air.

f. Other services aggregates 35 sectors, of which the top 15 in value are: (1) wholesale & retail trade, (2) motor trade, (3) real estate, (4) public administration, (5) other monetary intermediation, (6) telecommunications, (7) accommodation & food, (8) secondary education, (9) human health, (10) primary education, (11) professional, scientific & technical, (12) insurance & pension, (13) IT & other information, (14) other administration & support, (15) higher education, ………….., (35).

The economy has two primary energy sectors (electricity generation, and petroleum fuel), one of which —electricity generation— use energy more intensely[41]. Other energy-intensive industries include those that produce non-metal minerals, chemicals, rubber and

[41] The EU's regulations on pollution prevention defines an energy-intensive industry (or company) as one whose energy costs comprise 3% or more of the total production costs (see: UK's House of Commons. Hansard. Energy Intensive Industries (see: https://hansard.parliament.uk/commons/2016-03-10/ debates/16031031000002/ EnergyIntensiveIndustries). This definition has been used to estimate energy intensity.

plastics, leather, pharmaceuticals, wood, and metals. Finally, construction, transportation, and other services also consume relatively more energy.

The official detailed micro SAM for Kenya, 2009 has a total of 81 activities and commodities with some activities producing several commodities, and there are commodities that are generated by multiple activities. For the purposes of this study, these are aggregated into 34 activities/commodities (see Table 4-6): 1 agriculture, 3 services, and 30 industries. The industrial sector's disaggregation into 30 activities/commodities (two of which relate to primary energy) is appropriate for the intended purpose of this study, which is to empirically examine trade-induced sectoral specialization in dirty industries in the Kenyan economy.

The modeled economy has three primary factors of production; labor, capital, and land. The labor factor is disaggregated into unskilled, and skilled (includes, semi-skilled). There are three institutions (one households ―including enterprises―, government, and the rest of the world). The aggregated Kenya SAM 2009 that is verbally explained in Table 4-5 is a good description of the sources of the data that is used to calibrate the KenCGE Model's base year scenario. Finally, the Kenya SAM, 2009 is sufficient for this study, and does not require to be supplemented with data from external sources.

4.3.3. Structure of the economy

Table 4-7 presents the sectoral characteristics of Kenya's economy in 2009 ―the base year for the proposed study. The industry sector accounts for thirty-four of the eighty-one activities in 2009, in both energy-intensive, and non-energy intensive sectors. A country is classified as semi-industrialized if the composition of agriculture and services sectors' output exceeds 40% (Dervis, et al., 1982:262). As shown in column (2) of Table 4-7, this threshold is exceeded as Kenya's services sector, and agriculture sector, contributed 40.8%, and 17% of the 2009 output, respectively.

Table 4-7: **Structure of the Kenyan Economy in 2009**

	(1) O	(2) O'	(3) GDP	(4) GDP'	(5) VA	(6) D	(7) X	(8) M	(9) T	(10) EI	(11) OI/O	(12) VA/O	(13) X/O	(14) M/D
Agriculture	826	17.0	548	18.7	25.2	15.0	13.0	8.4	8.2	1.6	17.6	80.8	9.0	0.1
Primary energy														
Petroleum	79	1.6	-40	-1.3	0.8	4.6	2.1	12.6	28.9	0.5	73.8	25.7	15.0	0.4
Electricity	74	1.5	19	0.6	1.4	1.4	0.2	0.1	2.4	32.2	16.2	51.6	1.3	0.0
Energy-intensive														
Mining & quarrying	31	0.6	-48	-1.6	0.6	1.5	0.9	6.7	0.1	19.1	28.2	52.6	15.6	0.7
Non-metal minerals	40	0.8	0	0.0	0.4	1.0	1.8	1.5	0.7	10.1	62.7	27.1	25.7	0.2
Chemicals	66	1.4	-27	-0.9	0.8	2.6	4.3	8.8	2.0	11.7	126.6	61.7	93.6	1.0
Rubber & plastics	56	1.2	4	0.1	0.5	1.2	1.3	1.7	1.3	5.8	71.8	22.4	13.6	0.2
Water supply & sewerage	37	0.8	24	0.8	0.9	0.6	0.0	0.0	0.0	6.0	28.0	65.9	0.0	0.0
Leather	16	0.3	15	0.5	0.2	0.3	0.8	0.4	0.7	5.4	59.7	34.9	28.0	0.2
Paper and wood	53	1.1	-13	-0.5	0.5	1.4	0.8	2.4	0.7	7.9	142.3	49.8	16.7	0.4
Other (energy-intensive)	105	2.2	-30	-1.0	1.3	3.3	4.4	10.0	1.8	10.2	197.8	91.9	112.3	1.5
Non-energy intensive	719	14.8	568	19.3	8.6	19.7	26.8	38.1	39.4	1.3	66.9	31.8	21.3	0.3
Construction	311	6.4	264	9.0	4.1	5.2	0.0	0.0	0.0	4.3	61.1	34.6	0.0	0.0
Transport	467	9.6	350	11.9	7.8	8.0	20.2	1.4	2.9	22.8	33.1	44.1	24.8	0.0
Services	1,984	40.8	1,303	44.4	46.9	34.3	23.6	7.9	11.0	3.8	33.6	62.5	6.8	0.0
TOTAL	**4,866**	**100**	**2,938**	**100**	**100**	**100**	**100**	**100**	**100**					

Source: Author based on the Kenya's 2009 Social Accounting Matrix (SAM) provided by the Kenya National Bureau of Statistics

Notes:

Abbreviations: **O:** for gross output; **GDP:** for gross domestic product (market prices); **VA:** for value-added; **D:** for final demand; **X:** for exports; **M:** for imports; **T:** for import duties/tariffs; **EI:** for energy intensity; **OI:** for other intermediate inputs.

Column (1): Gross output (O), billions of 2009 KSh

Column (3): GDP, billions of 2009 KSh market prices

Columns 2 & 4-9: Percentage points (%) contributions to: gross output (O), gross domestic product (GDP), value-added (VA), final demand (D), exports (X), imports (M), and import duties/tariffs (T), respectively

Column 10: Energy intensity[42] (EI) is the ratio of primary energy to total activity expenditure times 100.

Columns 11-14: Ratios: other intermediate inputs to gross output, value-added to gross output, exports to output, and imports to final demand, respectively.

[42]Ibid.

Within the industrial sector, the non-durable food sector ―classified as non-energy intensive― dominate, followed by the following top five activities (basic metals, petroleum, electricity, rubber and plastics, and chemicals). Columns (4), (5), and (6) of Table 4-7 emphasize the important roles that services, agriculture, nondurable food, transport, and construction play in supporting GDP growth, value-added and total demand, respectively. Columns (7) and (8) show the sectoral trade orientation. All sectors have tradable goods and services, except for water supply and sewerage, and construction sectors. Interestingly, column (13) shows that energy-intensive and highly polluting goods (see column 10 for estimates of energy intensities), dominate the top positions in the ranking of the ratio of exports to output. Within the industrial sector, the energy-intensive industries include chemicals, pharmaceuticals, other non-food manufacturers, leather, non-metal minerals, metals, rubber and plastics, and paper products. The mining and quarrying sector, and the transport sector are also energy-intensive. The ratio of imports to aggregate demand appears to be more balanced (see column 14). Sectors with the highest ratio of imports to aggregate demand are chemicals, pharmaceuticals, mining, non-food manufacturers, petroleum, and metals products.

4.3.4. Exogenously determined parameters

There are certain parameters and exogenously determined variables (by assumption) that are estimated from external data sources. These are: the elasticity of substitution between domestic use and imports, the elasticity of transformation between domestic use and exports, and the elasticity of substitution in domestic commodity aggregation function. This thesis draws on academic literature for the needed values of these elasticities. Dervis, et al., (1982) provide trade substitution and price elasticities, while Löfgren (1994) surveys developing countries' elasticities for CGE models. Maskus, el al. (1997) have applied relevant substitution elasticities in their CGE model of Egypt to evaluate trade policy reforms in the context of the country's trade partnership with the European Union. Chapter 5 presents the assumed elasticity values that are used to calibrate the KenCGE Model.

4.4. Summary

This Chapter has presented the complete mathematical definitions of the KenCGE Model's equations, sets, parameters, and variables. The model is static and is developed to facilitate the quantitative exploration of the main channels through which deeper trade liberalization affects environment quality in Kenya. It uses the most recent dataset ―the KenSAM 2009―, and is adapted from the CGE model by Löfgren (1993), with modifications from Löfgren, et al., (2002). Moreover, theoretically, it follows the tradition of CGE models for open developing economies that were proposed by the World Bank (Dervis, et al., 1982). Based on the current state of academic literature, there does not appear to be a study on Kenya, that has used the methodology that is like the one underpinned by the KenCGE Model, and is described in this Chapter.

CHAPTER V: ANALYSIS AND RESULTS

Chapter five presents the outcomes of the assessment of Kenya's trade liberalization and environment policies. This investigation focuses on the assumed trade-off between trade liberalization and pollution abatement policies. It seeks to uncover whether such trade-offs could provide incentives for Kenya to specialize in dirty industries, to exploit its comparative advantages in trade. This Chapter starts by highlighting additional features of the model that was presented in Chapter IV, and importantly, presenting the experiments that underpin this study. Next is Section 5.2 that investigates the question whether further trade liberalization policy, alone, affects the pattern of trade specialization in Kenya and what, if any, are the implications for the country's environment. Thereafter, Section 5.3 analyzes the impacts of implementing an environmental tax policy, alone, on Kenya's international trade competitiveness. This is followed by Section 5.4 that assesses the implications of implementing joint policies of further trade liberalization, and pollution abatement, on the country's trade competitiveness, and the pattern of industrial specialization. Finally, Section 5.5 concludes.

5.1. The Experiments

The computable general equilibrium (CGE) model for Kenya in GAMS ―the KenCGE Model― that was presented in Chapter IV was employed to execute the experiments that inform the outcomes of this thesis. The KenCGE Model was calibrated to the base-run solution based on the data drawn from the 2009 Kenya's Social Accounting Matrix (KenSAM, 2009), as discussed in Chapter IV. However, the parameters related to the constant elasticities of substitution, and transformation functions, that are also required to calibrate the KenCGE Model were estimated, drawing on the works of Dervis, et al., (1982), Löfgren (1994), and Maskus, el al. (1997). From these academic sources, the following were judged as reasonable estimates for these parameters: the elasticity of substitution between domestic use and imports = 2; the elasticity of transformation between domestic use and exports = 5; and the elasticity of substitution in domestic commodity aggregation function = 4.

Table 5-1: **Policy Simulation – KenCGE Model**

Simulation	Description
Exp 1	2009 base-run
exp2	100% reduction in import tariffs
exp3	10% increase in energy (petroleum) inputs taxes
exp4	exp2 + exp3

Using KenCGE Model, four policy experiments (exp) were executed, as outlined in Table 5-1. The first experiment (exp1) is the 2009 base-run that is the reference competitiveness, pattern of specialization, and emissions path if Kenya does not change its trade liberalization and environment policies. As discussed in Chapter III, Kenya's has a robust policy on trade liberalization, and intends to further deepen its initiatives in this area. The KenSAM 2009 has a tariff rate of 12.4%. In contrast, Kenya's environmental management instruments are weak and vastly nonexistent. There is a tax that is paid by final consumers of petroleum products but the tax is not assigned as an environmental instrument. Kenya's prices of petroleum products are relatively lower compared to those of its neighbors, and are below the world average prices. The base-run experiment (exp1) results are not reported in this thesis; they, however, provided a counterfactual base for comparing the effect of policy shocks on macroeconomic variables, and sectoral changes in output, trade flows, and prices of factors and commodities.

The second experiment (exp2) comprises the implementation of a unilateral trade liberalization policy that entail a 100% elimination of import duties. This effectively equalizes the domestic and international prices of imports, and reduces the cost of imported commodities by 12.4%, compared to the 2009 base year. A substantial increase in imports of pollution-intensive consumer goods might reduce pollution by changing the production mix in Kenya's industrial sector, from dirtier to cleaner goods. However, there is a priori expectation that tariff reforms might also boost sectors with imported inputs, and this could lead to an expansion of activity output. On the downside, such an expansion in output might have adverse implications on the environment, through higher use of petroleum fuel inputs. In the third experiment (exp3), a restrictive 10% tax policy is imposed on the price of petroleum fuel inputs. A priori considerations suggest that a carbon tax on petroleum fuel will incentivize industries to reduce demand for pollution-intensive energy inputs. There is an expectation that this could also lower output of energy-intensive industries, and in the longer run, provide industries with the incentive to shift to cleaner energy sources. Finally, a joint reform (exp4) that brings together the two separate policies (exp2 + exp3), is implemented, but the net outcome of such a coordinated policy is difficult to predict, a priori. This is because sectoral responses to the tariff elimination, on the one hand, and those from the extra environmental tax on energy inputs, on the other, are unpredictable as they, separately, have divergent effects on the pattern of trade specialization and environmental outcomes.

5.2. Trade Liberalization Policy

This section reviews the results of the second experiment (exp2) that involves a policy of 100% elimination of import tariffs, alone, compared to the 2009 base-run.

Table 5-2: **Aggregate Short-Run Impact of Tariff and Energy Tax Reforms**

	% Change from base-run (exp1)		
Variable	**exp2**	**exp3**	**exp4**
Nominal GDP	-1.37	-0.40	-1.73
Real GDP	-0.64	0.01	-0.63
Imports (value, domestic currency)	-2.92	-0.42	-3.31
Exports (value, domestic currency)	2.37	1.23	3.46
Consumption demand in current prices	2.57	-0.95	1.71
Consumption demand in real terms	3.33	-0.53	2.85
Government revenues	-19.61	2.12	-17.63
Foreign savings	47.62	-7.80	40.32
Nonproduction labor real wage rate	3.68	-0.51	3.22

Macroeconomic effects: As shown in Table 5-2, trade reforms (exp2) that leads to full convergence of the domestic and world prices of imports, induces a small contraction in the real GDP of 0.64%, in the short-run, compared to the base-run. Also, the removal of tariffs caused reductions in nominal GDP by 1.37%, and the value of imports by 2.92%, and an expansion in the value of exports by 2.37%. The fall in the value of imports boosted industrial activities and consumer demand, and enhanced household welfare, as evidenced by the increase in real consumer demand by 3.33%. There was a substantial increase in foreign savings by 47.62%, compared to the base-run. However, the government was the main loser of the trade reform policy as its revenues fell by 19.61%, compared to the base-run, because of dwindling in revenues from taxes on commodities and international trade.

Sectoral effects: A tariff reforms policy has favorable effects on activity output, imports, and exports, as shown in Table 5-3, and by detailed data in Table 8-5 in Section 8.2 (Appendix 2). Broadly, evidence suggests that trade liberalization could incentivize Kenya to specialize in dirtier industries. The elimination of import tariffs stimulated growth in activity output across sectors. As a result, most industries recorded relatively higher increases in activity output, compared to the base-run, that ranged from 1%-10.7%. These include those that produce pharmaceuticals, bakery, rubber and plastics, and chemical products. Of these, the production of pharmaceuticals, rubber and plastics, and chemical goods require high use of energy inputs, specifically, of between 3% to 8.6% of production costs in the base year.

Conversely, trade liberalization reforms caused contraction in outputs, for example, in industries manufacturing paper, other foods, sugar, and wood products, and in mining and quarrying sector. These recorded output contractions of between 0.6%-2.8%. Thanks to the contraction, trade liberalization policy, could advance pollution abatement and mitigation goals, in energy-intensive industries producing paper, wood, and metals products, and in mining and quarrying activities. Other industries' output responses after trade liberalization fall in between these cases, but the storyline, regarding the environmental implications of the related changes in output is not that promising. Overall, a significant observation is that 10 out of 15 sectors in the 2009 baseline that are energy-intensive experienced positive output responses after trade was fully liberalized. Conversely, sectors that pollute less, for example, food manufactures, and agriculture, either recorded lackluster expansion in output or at worse contracted after the trade liberalization policy was effected. Consequently, from an output perspective, one would expect increasing pollution from scale effects, with further trade liberalization.

Table 5-3: **Sectoral Short-Run Impact of Tariff and Energy Tax Reforms**

	% Change from base-run (exp1)								
	Activity output			Quantity of imports			Quantity of exports		
Sector	**exp2**	**exp3**	**exp4**	**exp2**	**exp3**	**exp4**	**exp2**	**exp3**	**exp4**
Agriculture	-0.08	0.01	-0.07	28.49	-1.16	27.17	0.75	2.21	2.71
Mining and quarrying	-1.06	-0.11	-1.17	3.05	0.02	3.07	32.09	-0.30	31.73
Meat processing	0.20	-0.04	0.17	35.23	-1.77	33.09	-10.11	4.37	-6.60
Fish processing	0.05	0.14	0.17	30.51	-1.18	29.15	-0.97	1.13	0.03
Fruit and vegetable products	0.30	0.54	0.78	22.70	-0.49	22.18	3.41	1.14	4.41
Vegetable and animal oils/fats	0.55	0.16	0.71	14.82	-0.63	14.17	16.19	0.80	16.95
Dairy products	0.89	-0.12	0.79	30.61	-1.36	29.03	0.44	2.55	2.74
Grain mill products	0.09	-0.05	0.06	28.89	-1.52	27.18	0.86	3.62	4.05
Bakery products	3.65	-0.37	3.33	29.93	-1.41	28.27	11.55	2.24	13.90
Sugar manufacture	-1.11	0.02	-1.08	26.99	-1.26	25.59	-0.81	2.51	1.40
Coffee processing	-0.07	0.06	-0.01	32.64	-1.02	31.44	-0.83	0.37	-0.50
Tea processing	0.21	0.12	0.31	32.99	-1.21	31.56	-0.58	0.51	-0.13
Other food products	-2.75	0.28	-2.48	23.50	-1.03	22.39	3.46	2.37	5.62
Beverages products	0.59	-0.06	0.55	32.33	-1.51	30.55	-3.13	3.00	-0.51
Tobacco products	0.64	0.36	0.96	22.94	-0.88	21.97	1.82	0.63	2.37
Textiles and clothing	-0.12	0.06	-0.06	23.14	-0.80	22.28	5.42	1.07	6.37
Leather products	0.20	0.06	0.25	26.12	-1.06	24.95	2.95	1.24	4.07
Wood products	-0.61	0.00	-0.61	19.05	-0.26	18.80	16.72	0.56	17.26
Paper products	-1.92	0.10	-1.84	8.64	-0.03	8.62	27.91	0.30	28.21
Printing and reproduction	-0.07	0.02	-0.05	26.41	-0.37	26.01	4.87	0.91	5.69
Petroleum products	0.10	0.01	0.11	6.81	-0.42	6.42	31.37	0.67	32.02
Basic chemicals	1.31	0.10	1.41	3.48	-0.04	3.46	10.26	0.14	10.40
Chemical products	1.23	-0.43	0.86	14.74	-0.36	14.35	18.40	-0.25	18.21
Pharmaceuticals	10.69	0.55	11.34	8.21	-0.34	7.86	21.14	0.88	22.18
Rubber and plastics	1.55	0.02	1.60	14.43	-0.53	13.89	24.19	0.88	25.17
Other non-metal minerals	0.12	-0.03	0.10	13.41	-0.07	13.33	15.43	0.02	15.45
Metal products	-0.18	0.05	-0.13	8.22	-0.07	8.15	23.85	0.22	24.07
Machinery and equipment	0.15	0.03	0.18	2.68	-0.10	2.57	13.77	0.11	13.87
Other manufactures	-0.16	0.03	-0.13	16.68	-0.54	16.13	17.84	1.01	18.81
Power generation/ distribution	0.60	-0.48	0.17	28.28	1.49	29.89	3.77	-5.04	-0.73
Water supply and sewerage	0.20	-0.05	0.16	0.00	0.00	0.00	0.00	0.00	0.00
Construction	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00
Transport	0.38	-0.33	0.10	2.62	-0.84	1.84	-2.18	0.27	-1.88
Other services	-0.06	0.06	-0.02	3.30	-1.23	2.15	-6.49	2.66	-4.21

Although tariff reforms induced strong sectoral imports and exports responses as shown in Table 5-3, the responses were strikingly dissimilar. All sectors expanded their imports after trade reforms. However, imports in non-energy intensive sectors, expanded fastest, compared to the base-run scenario. Virtually all sectors related to food processing, and agriculture, that are relatively more protected through import tariffs recorded substantial increases in imports ranging between 23.5%-35.23% over the 2009 base-run. The only exception in the category of sectors that responded strongly in their demand for imports, and that use energy intensely, are: electricity generation and distribution (increase of 28.28%); leather production (increase of 26.12%); and wood products (an increase of 19.05%). With these exceptions, other energy-intensive sectors had lower imports responses after trade liberalization reforms, of between 2.62% to 14.74%.

Unlike on the imports side, where non-energy intensive sectors dominated in expanding their activity after trade reforms, Kenya's export growth was concentrated in pollution-intensive sectors (11 out of the 24). In this regard, after trade reforms, exports grew by between 21.14% to 32.09% in mining and quarrying whose activities are energy-intensive, and in energy-intensive industries involved in the production of paper, rubber and plastics, metals, and pharmaceuticals products. While most industries expanded their exports activity, there were eight industries that experienced contractions, two of which —transportation (contracted by 2.18%), and other services (contracted by 6.49%)— are energy-intensive. The non-energy intensive sectors that recorded export activity contractions of between 0.58% and 10.11% are in food manufacturing industries that process meat, beverage, fish, coffee, sugar, and tea products.

Interestingly, while exports expanded across all sectors of the economy after trade reforms, compared to the base-run, the quantity sold domestically of domestic output contracted across sectors. Importantly, most of the industries that diverted their output to exports, were energy-intensive. These include other non-metal minerals, paper, metals, pharmaceuticals, and basic chemicals. These energy-intensive industries, sharply reduced the supply of their goods to the domestic market, in favor of exports. The fact that Kenya's trade reforms intensify the production, for exports rather than domestic consumption, of energy-intensive and, therefore, potentially pollution-intensive goods, has a major implication on the level of emissions in the country.

The above analysis reveal that trade opening might enable Kenya to specialize in producing dirtier goods where it has a comparative advantage, because of lower opportunity costs. The experiments show that import response after trade reforms is lackluster in sectors that are energy and pollution-intensive. Conversely, spectacular growth in imports emerge in sectors that are associated with lower energy intensities, and are more labor intensive, such as food manufactures and agricultural activities. Recall from Chapter III that Kenya imposes punitive tariffs, ranging between 35% and 100% on some imports in sectors that are classified as sensitive —for example, cereals, sugar, and textiles and clothing. Simulation in exp2 show that with further trade opening, imports in these and other sectors that have lower-carbon emissions in the Kenyan economy could grow at a faster pace than in sectors with high-carbon emissions. Conversely, on the exports side, this situation is reversed; substantially high growth was achieved in energy-intensive sectors, that pollute more, than in sectors that are associated with lower-carbon emissions.

Impact on households: At the macro and sectoral levels, freer trade is welfare enhancing. In real terms, consumer demand increased by 3.33%, and nonproduction labor wage rate by 3.68%, compared to the base-run (see Table 5-2). At the sectoral level, the real wage rate for production labor increased substantially in virtually all sectors compared to the base-run (see Section 8.2, Appendix 2, Table 8-6). Mining and quarrying sector and three industries —other foods, wood products, and paper products, however, recorded contractions in the real wages of between 0.48% and 8.96%. The top three industries that recorded the highest growth in production labor wages, were those producing pharmaceutical, meat, and bakery products, where the real wage rate rose by 25.8%, 21.54%, and 20.82%, respectively, compared to the base-run. However, increased output in dirty industries would intensify pollution, and in the longer-term lead to detrimental effects on public health and labor productivity. Such developments have negative impact on social welfare.

Impact on environment: The analysis of the existing trade patterns as documented in Chapter III reveal that Kenya's exports are dominated by primary commodities and labor-intensive manufactured goods, while capital-intensive goods dominate on the imports side. Is this pattern of trade specialization likely to change if a trade reform policy, alone, is implemented? And if so, what are the implications for Kenya's environmental quality? The analysis so far seems to suggest that, yes, the pattern would change if trade reforms involve removal of all trade tariffs. Without any further analysis or environmental policy actions, it appears that Kenya is likely to specialize in the production of dirtier goods, as it intensifies its exports in relatively dirtier goods, after trade liberalization. Further, it is evident that imports in the Kenyan case are not a substitute instrument for abating pollution when trade is fully liberalized as exp2 show that imports in cleaner sectors rise relatively faster than those in dirtier sectors. In summary, further trade liberalization policy, alone, would increase the country's pattern of specialization towards dirty industries if Kenya does not take concrete actions to implement complementary pollution abatement actions to mitigate pollution that is likely to emerge with further trade opening.

5.3. Pollution Abatement Policy

The third experiment (exp3) involved a policy change that imposes a 10% environmental tax on petroleum (energy) inputs to curtail harmful emissions, compared to the 2009 baseline. The experiment for this standalone policy change on energy taxes was conducted under the assumption of no further trade liberalization.

Macroeconomic effects: The short-run effects of this restrictive environmental tax policy, on aggregate variables are presented in Table 5-2. Under the pollution abatement policy (exp3), alone, there was a small increase in real GDP by 0.01% from the 2009 base scenario, a far better result than the contraction of 0.64% that was experienced under a trade reform policy, alone (exp2). The nominal GDP, however, contracted by 0.4% after the environmental tax policy was effected, but at a slower pace than the contraction experienced under the trade reforms policy, alone of 1.37% compared to the base-run. Furthermore, compared to the 2009 base-run, foreign savings contracted sharply by 7.8% unlike in exp2 where such savings increased by 47.62%. Finally, government revenues, compared to the base-run, increased by 2.12%, unlike in exp2 where such revenues declined by 19.61%.

Under an environmental tax policy alone, there are several effects that feed back to depress real GDP growth. First, the assumption that capital is sector specific impedes sectoral reallocation of capital and amplifies impacts on the macroeconomic variables because of a restrained equilibrating process. Furthermore, in the base 2009 economy, Kenya is an oil importer, and, therefore, the higher energy prices have a higher adverse effect on energy-intensive production and consumption. These adverse effects are reflected in contraction in nominal GDP (reduced by 0.4%), and nominal consumption (reduced by 0.95%), as shown in Table 5-2. The value of exports expanded, however, by 1.23%, but this increase, compared to the base-run, was about half of the increase in exports of 2.37% under trade reforms, alone (exp2). The government was the main beneficiary of the environmental tax policy as its revenues increased by 2.12% in exp3 as compared to the reduction of 19.61% under the trade reforms policy only (exp2) because of the mobilization of both environmental and international trade taxes. Conversely, households were the main losers of the standalone environmental tax policy. This is reflected in the decline in real consumer demand, and real nonproduction labor wage rate by, respectively, 0.53% and 0.51% under exp3 compared to an increase of 3.33% and 3.68%, under the trade reform policy, alone (exp2).

Sectoral impacts: Results in Table 5-3, and Table 8-5 in Section 8.2 (Appendix 2) show that an environmental tax on energy inputs has, broadly, adverse effects on output, and trade flows. Compared to the trade reform policy, alone, the standalone environmental tax policy reform caused the activity output across sectors to expand at a slower pace, of less than 1%, as data in Table 5-3 demonstrate. For example, the pharmaceutical industry, that had achieved a substantial activity output expansion of 10.69% under the trade reform policy alone, responded weakly under the environmental tax policy alone with an activity output growth of only 0.55%, compared to the base-run. As expected, far fewer energy-intensive industries expanded their output under the environmental tax policy. In the top five position, only the pharmaceutical industry, that is pollution-intensive, maintained its stronger output expansion response to the environmental tax policy reform, alone. This contrasts with the trade reform policy, alone, where more energy-intensive industries responded strongly in expanding their production capacities. The electricity (power) generation and distribution, transportation, and chemicals sectors that rely heavily on fuel were most adversely affected by the environmental tax policy.

Another interesting comparison between the output performance under trade reforms alone, and an environmental tax alone, is the variation in outcomes. Data in Table 5-3 show that under the trade reform policy, alone, the range of industrial output response was wider (contraction: -0.48%; expansion: 10.69%), compared to the range under the environmental tax policy, alone, (contraction: -1.69%; expansion: 0.55%). This suggests that in the Kenya case, an environmental tax policy is a better, and more targeted instrument for pollution abatement than the trade policy reforms policy. Indeed, a closer scrutiny of the output data reveal that the response of activity output to the energy tax, alone, is more evenly spread across industries (both energy-intensive and non-energy intensive) compared to the case of the trade reform policy, alone.

Regarding trade flows, performance vary across sectors of the economy, but generally, imports and exports activity decline (see Table 5-3). On the imports side, only two sectors marginally increased their imports under the energy tax policy; electricity (power) generation and distribution (by 1.49%) and mining and quarrying (by 0.02%), both of which are energy-intensive. On the exports side, higher production costs caused the following energy-intensive industries to curtail activities; electricity (power) generation and distribution (by 5.04%), and chemicals (by 0.25%). Also, exports from the mining and quarrying sector, that is also energy-intensive, contracted by 0.3%. Other industries in the tradable sector increased exports by between 0.02% and 4.37%, with all the energy-intensive ones increasing their exports at rates below average, except for other services sector that expanded its exports by 2.66%.

These results suggest that without mitigating actions, an environmental tax policy in the form of an energy tax, alone, could harm Kenya's international trade competitiveness. The outcomes of exp3 show that a 10% increase in the price petroleum fuel, which is viewed as harmful to the environment, imposes substantial costs on the Kenyan economy in terms of reduction in trade flows of both imports and exports, activity output, and the prices of labor. It is unlikely, without compensatory measures, that the Kenyan public would readily accept to bear the cost of increased energy prices, even if they have heightened environmental awareness.

Impacts on households: At the aggregate level, compared to the base-run, the energy tax policy caused household welfare to fall, as real consumer demand contracted by 0.53%. This is a worse off outcome for consumers as under the trade liberalization policy, their real consumption had increased by 3.33% compared to the base-run. Another source of declining welfare for household arose from the contraction of the real wage rate for nonproduction labor, by 0.51% compared to the base-run, and an increase of 3.68% under the trade reform policy, alone. At the sectoral level, an energy tax is not welfare enhancing, as well. The real wage rate for production labor contracted across the sector after the energy tax was imposed, compared to a clear pattern of increases across sectors under the trade liberalization reforms (see Section 8.2, Appendix 2, Table 8-6).

These results illustrate that an environmental tax has adverse effects on sectoral output. As production costs rise because of rising energy prices, enterprises scale back their activities, leading to declining overall output and use of primary labor factors. This causes an overall fall in the wage rate, and consequently, household incomes. In this analysis, however, it is not possible make deeper analysis of the effects of the policy shocks on households' welfare, because households are not disaggregated into quintile income groups. On the positive side, however, lower output and the likelihood of a cleaner environment might in the longer term have beneficial effects on public health and the productivity of labor, and consequently, lead to enhanced social welfare.

Impact on environment: Although there are unfavorable effects of the environmental tax policy, alone, on Kenya's international trade competitiveness, such a policy has positive effects on environmental quality. Evidence of decline in aggregate domestic output, in energy-intensive industries, after the implementation of an environmental tax policy, suggest that the pollution intensity of output will decline through scale effects. As such, compared to the 2009 baseline, the higher energy taxes would cause a decrease in emissions of carbon dioxide (CO2), and ambient particulate matter (PM10). A reduction in PM10 will in turn have favorable effects on public health. However, estimates of the reductions of these emissions, after an environment tax policy is introduced, is an empirical question that is outside the scope of this study.

5.4. Policy Coordination

Table 5-2 shows the effects of a policy that combines a 10% environmental tax on fuel products, and 100% import tariffs cut (exp4).

Macroeconomic effects: The impact of the coordinated policy on the macroeconomic variables is more moderated compared to outcomes under separate policies. Abolition of tariffs reduce the prices of imported inputs and final goods, and foster higher trade. This dampens the economy-wide negative effects of the higher energy prices that arise because of the environmental tax. As Table 5-2 illustrate, the real GDP responded to the joint policy by contracting marginally by 0.63%, compared to the base-run. Government revenues contracted sharply by 17.63% because the loss in revenues from the tariff cuts (a decrease of 19.61% per exp2) was only partially offset by the extra resources that were mobilized from the environmental tax (an increase of 2.12% per exp3). Both the domestic value of exports (increase of 3.46%), and the domestic value of imports (decrease of 3.31%) under the joint policy depict a far better terms of trade position compared to the stand-alone policies. Finally, the real consumer demand increased by 2.85% under the joint policies compared to a deterioration under an environment policy alone.

Sectoral effects: Compared to the environmental tax policy alone, there is considerable improvement in the sectoral effects of the coordinated policy (see Table 5-3, above, and detailed data in Table 8-5 in Section 8.2 of Appendix 2). Regarding activity output, the responses of the coordinated policy are evenly distributed across sectors, unlike in the case of stand-alone policies where responses are clustered in unique patterns. Table 5-3 show that industries that achieved above average output outturns that ranged between 1.44% to 11.34% under the coordinated policy are those that produce pharmaceuticals, bakery, rubber and plastics, and basic chemicals products. The pharmaceutical industry recovered strongly by achieving an activity output growth of 11.34% under the coordinated policy, compared to the slow-down of 0.55% under the environmental tax policy, alone. The top five sectors whose output contracted the most under the coordinated policy are mining and quarrying, and those that cover industries producing wood, paper, sugar, and other food products. These contracted by between 0.61% and 1.56%, compared to the base-run. It is noticeable that under the coordinated policy, there is no systematic pattern of specialization of activity output, as energy-intensive industries feature in both expanding (for example, pharmaceutical and chemicals), and contracting (for example, wood production), and in mining and quarrying activities.

Under the coordinated policy, tariff cuts benefit output more, while the effects of higher energy prices are still evident, with energy-intensive sectors being negatively impacted more than non-energy intensive sectors. As shown in Table 5-3, despite all sectors expanding their imports under the coordinated policy, the energy-intensive ones faired far worse than non-energy intensive ones; only two energy-intensive sectors —electricity (power) generation and distribution, and the production of leather products— had import expansion above 20% under the coordinated policy, compared to the base-run. On the exports side, the pattern of distribution of responses to the coordinated policy show a relatively more symmetrical distribution of energy-intensive industries, although more industries expanded their activities than those that recorded contractions. The mining and quarrying sector, and industries producing paper, rubber and plastics, metal products, and pharmaceuticals expanded their exports by above average rates. The energy-intensive industries that achieved contraction in export growth are electricity generation, transportation, and other services. These outcomes demonstrate the balanced nature of the coordinated policy unlike under the stand-alone policies where outcomes depict patterns of specialization in activity outputs and trade flows.

Impact on households: The coordinated policy still has negative effects on households when compared with the stand-alone trade policy, but broadly, is welfare improving. As shown in Table 5-2, the real consumer demand increased by 2.85% compared to the base-run, a far better performance compared to the stand-alone environmental tax policy where such demand contracted by 0.53%. This, however, is a weaker performance compared to the higher real consumer demand of 3.33% that was reached under the trade reform policy, alone, compared to the base-run. At the macro level, the real wage rate for nonproduction labor increased by 3.22% compared to the base-run. This is slightly less than the level achieved under the trade reforms policy alone (an increase of 3.68%), but a far better result than the outcome under the environmental policy (a contraction of 0.51%). At a sectoral level, the real wage rate for production labor under the coordinated policy increased across all sectors except in four (other foods, wood products, mining and quarrying, and paper) (see Section 8.2, Appendix 2, Table 8-6). These outcomes are far better for households than the contraction experienced under the environment policy alone.

Environmental effects: The implications of implementing joint policies of further trade liberalization, and pollution abatement, on the environment are similar to those achieved under an environmental policy, alone. However, the environmental impacts are expected to be more moderated under the coordinated policy, as compared to the policy of environmental tax, alone.

5.5. Summary

The removal of trade tariffs has a favorable effect on sectoral output and trade flows, but increases the risks that Kenya might specialize in dirty industries. On the other hand, sectors that are energy-intensive are more negatively impacted by an environmental tax on energy inputs. Although the adverse effects of an environmental tax policy do not dissipate under the joint policy, the impact on macroeconomic and sectoral variables are dampened. Sectorally, the effects of a coordinated trade-environment policy will depend on energy intensities and trade orientation, but broadly, the benefits of a coordinated policy are evident.

CHAPTER VI: CONCLUSION

This thesis moves forward the discourse on the consequences of outward oriented trade policy on the environment. It advances the debate on the assumed trade-off between trade liberalization and environmental quality using the case of Kenya, a new entrant to middle income country status, and a country that is aggressively pursuing industrialization as an instrument for enabling its citizens to reap the dividends of globalization. Understanding the linkages between trade-driven growth and environmental quality is important for evidence based policy responses, particularly for developing countries, such as Kenya, with low institutional, and implementation capacities, for environmental management. In respect of Kenya, a progressively industrializing developing country, it is of uttermost urgency that policy makers have evidence based prescriptions on optimal policies that would strike the right balance between expanding trade liberalization, while controlling trade-driven industrial pollution. Such evidence based policy prescriptions are, however, curtailed by the scarcity of theoretically founded research on Kenya, as is for many developing economies.

A Computable General Equilibrium Model for Kenya (the KenCGE Model) was developed, as part of this thesis, to close the gaps in the literature. Technically, founded on the Löfgren (1993)'s static open economy general equilibrium model for Egypt, the model is theoretically grounded on the tradition of the World Bank's neoclassical CGE models (see Dervis, et al., 1982). The model is developed taking Kenya's economy as open, under a small country assumption where world prices for the country's imports and exports are given. Domestic factor and product markets are taken as perfectly competitive. The model is calibrated using the Social Accounting Matrix for Kenya, 2009 (KenSAM, 2009), and is simulated to run on the GAMS (General Algebraic Modeling System) software (see Brooke et al., 1988). The KenCGE Model incorporates a detailed definition of the industrial sector ―thirty, out of thirty-four sectors―, structural characteristics (markets for goods, labor, capital, and land), and institutions (one household ―incorporating enterprises―, the government, and the rest of the world). The

KenCGE Model was used to analyze the effects of three policy choices: a 100% cut in import tariffs, alone; a 10% environmental tax on petroleum inputs, alone; and a combined trade reforms and environmental tax policies.

6.1. Key Outcomes

Trade reforms —100% elimination of import tariffs— as an instrument for abating pollution lead to several short-run responses. At the macro level, real GDP (Gross Domestic Product) decline by 0.64%, as domestic and international prices converged under the small country assumption. At the sector level, trade reforms, alone, induce output specialization towards dirtier industries, and consequently, has the potential to increase pollution through scale effects. Above average output increases (range of between 1%-11.7%), over the base-run, were noticed in industries that are energy-intensive such as pharmaceuticals, rubber and plastics, and chemical products. Further, out of the 15 industries that are categorized as energy-intensive, only 5 had activity output reductions after trade was fully liberalized. This suggest that trade reforms in Kenya increases the risk of specialization in dirtier industries, as 67% of energy-intensive industries had positive output responses.

Trade tariff reforms, alone, induced strong imports and exports responses across tradeable sectors, compared to the base-run. While imports increased in all sectors, non-energy intensive sectors, for example food processing and agriculture, expanded their imports at a faster pace. On the exports side, the responses induced by trade reforms were mixed. Surprisingly, stronger positive responses in exports were noticeable in energy-intensive sectors. These include mining and quarrying, and the production of rubber and plastics, paper, metals, and pharmaceuticals products. Unlike in the case of imports, only a handful non-energy intensive sectors —these are vegetable and animal oils and fats, machinery and equipment, bakery products, and other manufactures— achieved noticeable increases in exports after trade reforms, compared to the base-run.

There was evidence of diversion of output of energy-intensive industries (for example, basic chemicals, and pharmaceuticals) to exports, from the domestic market, after trade opening reforms. This is a highly significant finding as trade reforms incentivized dirty industries to intensify exports of dirtier goods, while curtailing supply to the domestic market. This, in turn, has the potential of increasing the level of pollution in the Kenyan economy, after full trade liberalization is realized. In sum, under exp2, compared to the base-run (exp1), trade reforms, alone, induced in most sectors increases of activity output, imports, and exports. Although exports expanded in 24 out of 32 tradable sectors, imports increased in all tradable sectors. The diversion of trade to the export caused the quantity of goods supplied domestically, from the domestic output, to contract in most industries. With domestic and international prices, having converged after Kenya's trade was fully liberalized, product prices across all sectors fell. The falling domestic prices caused an in increase net exports as domestic goods became more competitive in international markets. This suggests that trade reforms, alone, increases the risk that the Kenyan economy might specialize in dirty industries. This would intensify emissions, if no complementary mitigating policy actions are taken to protect the environment.

Finally, a trade liberalization policy, alone, enhances economic welfare. At the macro level, real consumer demand, and the real nonproduction labor wage rate, increased by 3.33%, and 3.68%, respectively. Sectorally, the real wage rate for production labor increased in virtually all sectors. The higher real wages translate into rising real incomes and, consequently, higher economic welfare of household. Conversely, increased output that is induced by trade liberalization might lead to intensification of pollution, and this has adverse consequences on social welfare.

A policy of pollution abatement that entails levying a 10% energy input tax, alone, resulted in a small increase in real GDP by 0.01%. At the sector level, the environmental tax had mixed results. Most of the energy-intensive sectors posted relatively weaker output increases, while a few contracted (for example, mining and quarrying, transportation, chemicals, and electricity generation). Imports in energy-intensive sectors declined, with two exceptions where small increases were noted (electricity generation, and mining and quarrying). Finally, exports responded weakly, with notable, below average increase responses from energy-intensive industries. These results suggest that without mitigating actions, an energy tax policy alone, might cause significant damage to Kenya's international trade competitiveness.

An energy tax, alone, does not enhance economic welfare. At an aggregate level, real consumer demand declined by 0.53%, and this adversely impacted consumer welfare. Real wages for labor factors contracted in tandem with economic output downturn. These outcomes unfavorably impacted households' welfare, compared to the base-run. On a positive note the decline in aggregate domestic output, after the energy policy reform, is expected to result in decline in pollution of energy-intensive industries, and this might, in the longer-term, contribute to a cleaner environment and improved social welfare.

The final experiment is a coordinated policy reform that comprises a 100% cut in tariffs, and a 10% tax on petroleum fuel inputs. This resulted in contraction of real GDP by 0.63%. Generally, changes in aggregate variables under joint policy reform, were more moderated compared to the stand-alone reforms on trade and the environment. Further, the sectoral activity output outcomes of the joint policy change improved, though they varied depending on sector specific energy intensities. Exports also increased in most sectors. However, because of diversion of trade from the domestic to foreign markets, the quantity of domestic output sold domestically declined across sectors, compared to the base-run. As is in the case of the trade policy alone, the joint policy appears to cause an increase in net exports because of increasing competitiveness of the domestic goods in world markets. However, the environmental component of the joint policy might mitigate the risk of specialization in dirty industries that Kenya is faced with under a trade liberalization policy reform, alone.

In conclusion, industrial responses to the coordinated policy lead to a more evenly distributed activity outputs across sectors. This suggests that the significant patterns of specialization in production that arose under the trade policy, alone, have been mitigated through policy coordination. Tariff cuts were beneficial to output, while the effects of higher energy prices are still evident with energy-intensive industries being relatively more negatively impacted than non-energy intensive ones. Despite economy wide expansion of imports under the coordinated policy, all energy-intensive sectors faired far worse than non-energy intensive ones. The welfare of households increased under the coordinated policy, as reflected in the improvement in real consumer demand unlike in the case of an environmental tax policy, alone, where real consumption demand contracted. This, however, was a weaker performance as under the trade reform policy alone, the real consumer demand was higher. Finally, given that environmental policy reforms are included in the joint policy, growth in output is bound to occur in a sustainable cleaner environment, and this, in the longer-term will enhance social welfare. These findings are in stark contrast with those of Gumilang, et al. (2011) who concluded that the impact of deepening Indonesia's trade liberalization on the environment was insignificant. The findings, however, demonstrate the advantages of coordinating trade and environmental policies.

6.2. Policy Implications

Kenya is currently, a low emitter of greenhouse gases. As such the concerns relating to the inevitable growth-environment trade-off (Beghin, et al., 2002b) that Kenya is currently faced with are manageable, as the country's industrial emissions have not reached a critical level. The analysis in this thesis suggest that there is need for "caution" (Beghin, et al., 2002b:4), if Kenya were to manage the transition to industrialized status through a sustainable trade opening growth path that is also environmental friendly. To address the challenges posed by the risks of specialization in dirty industries, the analysis presented in this study, as in Beghin, et al., (2002b), suggest that Kenya will need to coordinate its trade opening policy with an appropriate pollution abatement policy. Kenya should, therefore, incorporate in its environmental policy tools, specific economic instruments that address directly environmental concerns.

To overcome emerging environmental challenges that might arise from further trade liberalization, an energy tax or a carbon tax on petroleum fuel inputs and new sources of hydrocarbon fuels such as coal, should be considered as a key policy instrument for abating pollution. The carbon tax, should target energy-intensive industries, but could be calibrated at different rates across sectors based on the objectives the environmental policy seeks to achieve, and in consideration of the country's growth, and household welfare objectives. As the Kenyan public is likely to oppose such a new tax, incentives could be incorporated to channel part of the additional revenues that are mobilized from the carbon tax, to subsidies for low income households and public transportation. The Kenya's National Environment Management Authority (NEMA) should use the balance of the revenues from the carbon tax to reinforce its capacity to monitor, and control industrial pollution.

6.3. Other Matters for Consideration

The KenCGE Model is particularly strong in supporting policy makers in Kenya in their quest to implement optimal economic policies in the areas of trade and industrial pollution. The model's household sector, however, is highly aggregated and, therefore, it can only provide broad insights on the impact of trade and environmental quality on household welfare. Disaggregation of households into various income quantiles is an enhancement that is essential for the model to provide insights of the impact of policy changes on various income groups. Another area that disaggregation could be helpful relates to labor factors. Collectively, such disaggregation would enhance the economic and welfare related policy prescriptions that arise from the analysis of the linkages between trade liberalization and environmental policies.

The focus of the model was on identifying the impact on patterns of industrial specialization of a trade opening policy, on the one hand, and a pollution abatement policy, on the other. The next logical step is for the model to be enhanced to account for further environmental impacts by connecting emissions to both the use of primary inputs ―petroleum and electricity―, and the final consumption demand (see Beghin, et al., 2002b). In this case, Beghin, et al (1996) approach is informative. Further, as in Beghin, et al (1996), the model's structure could be made dynamic in the areas of accumulation of productive factors (capital and labor), and technological growth. This is important because emissions abatement technology play an important part in both enhancing production processes, and in the design of a robust environmental policy.

VII. REFERENCES

Akbostanci, E., Tunc, G. I., & Türüt-Asik, S. (2007). "Pollution haven hypothesis and the role of dirty industries in Turkey's exports." *Environment and Development Economics*, 12(02), 297-322.

Akinboade, O. A. (1993). "Technical Efficiency Change in Kenyan Agriculture and the Poor: A Computable General Equilibrium Analysis." *African Development Review*, 5(2), 1-19.

Alcamo, J., Leemans, R. and Kreileman, G.J.J., 1998. *Global change scenarios of the 21st century. Results from the IMAGE 2.1 model.* Pergamon & Elseviers Science, London.

Anderson, K., and R. Blackhurst (1992). *The Greening of World Trade Issues.* Ann Arbor MI: University of Michigan Press, 1992.

Antweiler, W., Copeland, B.R., Taylor, M.S. (2001). "Is free trade good for the environment?" *American Economic Review*, 91, pp. 877–908.

Armington, P. S. (1969). *A Theory of Demand for Products Distinguished by Place of Production (Une théorie de la demande de produits différenciés d'après leur origine)(Una teoría de la demanda de productos distinguiéndolos según el lugar de producción).* Staff Papers (International Monetary Fund) Vol. 16, No. 1 (Mar., 1969), pp. 159-178.

Balistreri, E. J., Jensen, J., & Tarr, D. (2015). "What determines whether preferential liberalization of barriers against foreign investors in services are beneficial or immizerising: Application to the case of Kenya." *Economics: The Open-Access, Open-Assessment E-Journal*, 9(2015-42), 1-134.

Batabyal and Nijkamp (2010). *Research Tools in Natural Resource and Environmental Economics.* Edited by: Amitrajeet A Batabyal (Rochester Institute of Technology, USA), Peter Nijkamp (VU University Amsterdam, The Netherlands). World Scientific Publishing Co Pte Ltd.

Beckerman, W. (1974). *In Defence of Economic Growth*, Jonathan Cape Ltd. London.

Beghin, J., Bowland, B. J., Dessus, S., Roland-Holst, D., & Van der Mensbrugghe, D. (2002a). "Trade integration, environmental degradation, and public health in Chile: assessing the linkages." *Environment and Development Economics*, 7(02), 241-267.

Beghin, J., Dessus, S., Roland-Holst, D., & Van der Mensbrugghe, D. (1996). "General Equilibrium Modelling of Trade and the Environment." *OECD Development Centre Working Papers*, No. 116, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/345585702835.

Beghin, J., Roland-Holst, D. & Van der Mensbrugghe, D. (1994). "A survey of the trade and environment nexus: global dimensions." *OECD Economic Studies* 23, no. Winter (1994): 167-92.

_________ (1995). "Trade liberalization and the environment in the pacific basin: Coordinated approaches to Mexican trade and environmental policy." *American Journal of Agricultural Economics*, 77, 778-785.

Beghin, J., Roland-Holst, D. & Van der Mensbrugghe, D. (2002b). *Trade and the Environment in General Equilibrium: Evidence from Developing Economies.* Kluwer Academic Publishers, The Netherlands.

Benarroch, M., & Gaisford, J. (2014). "Intra-industry Trade Liberalization and the Environment." *Review of International Economics*, 22(5), 886-904.

Birdsall, N., & Wheeler, D. (1993). "Trade policy and industrial pollution in Latin America: where are the pollution havens?" *The Journal of Environment & Development*, 2(1), 137-149.

Blackhurst, R., & Subramanian, A. (1992). "Promoting multilateral cooperation on the environment." In *K. Anderson & R. Blackhurst (Eds.), The Greening of World Trade Issues*. London: Harvester Wheatsheaf, pages 247-268.

Bohm, P., & Russell, C. S. (1985). "Comparative analysis of alternative policy instruments." Chapter 10 in *Handbook of Natural Resource and Energy Economics*, 1985, vol. 1, pp 395-460 from Elsevier.

Bommer, R. (1999). "Environmental Policy and Industrial Competitiveness: The Pollution- Haven Hypothesis Reconsidered." *Review of International Economics*, 7(2), 342-355.

Bragga, C. A. P. (1992). "Tropical forests and trade policy: The case of Indonesia and Brazil." In P. Low (Ed.) *International trade and the environment* (World Bank Paper No. 159, pp. 173-193). Washington, DC: World Bank.

Brooke, Anthony, David Kendrick, Alexander Meeraus, and Ramesh Raman (1998). *GAMS: A User's Guide.* GAMS Development Corporation, 1998. Washington, DC, USA. http://www.gams.com/.

Brunnermeier, S. B., & Levinson, A. (2004). "Examining the evidence on environmental regulations and industry location." *The Journal of Environment & Development*, 13(1), 6-41.

Carraro, C. (1999). "Imperfect markets, technological innovation, and environmental policy instruments." In J. C. J. M Van den Bergh (Ed.), *Handbook of environmental and resource economics* (pp. 235-248). Cheltenham, UK: Edward Elgar.

Central Bank of Kenya (2015). *Kenya Monthly Economic Review*, January 2015. Available online at: http://www.centralbank.go.ke.

Chang, N. (2012). “The empirical relationship between openness and environmental pollution in China.” *Journal of environmental planning and management*, 55(6), 783-796.

Cole, M. A. (2004). “Trade, the pollution haven hypothesis and the environmental Kuznets curve: Examining the linkages.” *Ecological Economics*, 48, 71-81.

Cole, M.A., & Elliot, R.J.R. (2003a). “Do Environmental Regulations Influence Trade Patterns? Testing Old and New Trade Theories”, *The World Economy*, 26, 8, 1163–86.

_________ (2003b), “Determining the trade-environment composition effect: the role of capital, labor and environmental regulations.” *J. Environ. Econ. Manage.*, 46 (3), pp. 363–383.

_________ (2005). “FDI and the capital intensity of “dirty” sectors: a missing piece of the pollution haven puzzle.” *Review of Development Economics*, 9(4), 530-548.

COMESA (2015a). *About COMESA and History of COMESA.* Available Online At: http://about.comesa.int/ (Accessed, September 1, 2015).

_________ (2015b). *Trade, Customs and Monetary Affairs.* Dick Elleray, Staff of COMESA. Available online at: http://programmes.comesa.int/ (Accessed, August 31, 2015).

_________ (2015c). *The COMESA-EAC-SADC Tripartite Summit 2015.* Available online at: http://www.comesaria.org/events/the-comesa-eac-sadc-tripartite-summit-2015.71.124.html.

_________ (2015d). *Brief on the COMESA Customs Union.* The COMESA Customs Union. Available online at:http://programmes.comesa.int/index.php?option= com_content &view=article&id=90&Itemid=142.

Condon, T., Dahl, H., & Devarajan, S. (1987). *Implementing a Computable General Equilibrium Model in GAMS: The Cameroon Model*: Development Research Department. Economics and Research Staff, World Bank.

Copeland, B. R. (1994). “International trade and the environment: policy reform in a polluted small open economy.” *Journal of Environmental Economics and Management*, 26(1), 44-65.

Copeland, B. R., & Taylor, M. S. (1994). “North-South trade and the environment.” *The Quarterly Journal of Economics* (1994) 109 (3): 755-787. doi: 10.2307/2118421.

_________ (1995). “Trade and transboundary pollution.” *The American Economic Review*, 1995, vol. 85, issue 4, pages 716-37.

_________ (2004). “Trade, growth and the environment.” *Journal of economic literature*, XLII(March): 7–71.

Corden, W. M., & Falvey, R. E. (1985). “Quotas and the second best.” *Economic Letters*, 18, 67-70.

Daly, H. E. (Ed.). (1973). *Toward Steady-state Economics.* WH Freeman & Co., San Francisco.

Dasgupta, S., Laplante, B., Wang, H., & Wheeler, D. (2002). “Confronting the environmental Kuznets curve.” *The Journal of Economic Perspectives*. 2002 Jan 1; 16(1):147-168.

Dasgupta, S., & Wheeler, D. (1997). *Citizen complaints as environmental indicators: evidence from China* (Vol. 1704). World Bank Publications.

De Bruyn, S. M., van den Bergh, J. C., & Opschoor, J. B. (1998). “Economic growth and emissions: reconsidering the empirical basis of environmental Kuznets curves.” *Ecological Economics*, 25(2), 161-175.

Dean, J. M. (2002). “Does trade liberalization harm the environment? A new test.” *Canadian Journal of Economics/Revue canadienne d'économique*, 35(4), 819-842.

Dervis, K., J. de Melo, and S. Robinson. (1982). *General equilibrium models for development policy.* New York: Cambridge University Press.

Dessus, S., & Bussolo, M. (1998). “Is there a trade-off between trade liberalization and pollution abatement?: a computable general equilibrium assessment applied to Costa Rica.” *Journal of Policy Modeling*, 20(1), 11-31.

Dietzenbacher, E., & Mukhopadhyay, K. (2007). “An empirical examination of the pollution haven hypothesis for India: towards a green Leontief paradox?” *Environmental and Resource Economics*, 36(4), 427-449.

Di Falco, S., & Marangon, F. (2012). “Economic incentives for pollution control in developing countries: what can we learn from the empirical literature?.” *Politique Agricola Internazionale* (PAGRI). 2012;2(2):7-24.

Dixon and Jorgenson (2013). *Handbook of Computable General Equilibrium Modeling*, Volume 1A (Handbooks in Economics) 1st Edition by Peter B. Dixon (Editor), Dale Jorgenson (Editor). North Holland.

EAC (2007). *East African Community, Common External Tariff.* 2007 Version. Available online at: http://www.kra.go.ke/customs/pdf/EAC%20Externaltariff2007.pdf.

Ederington, J., Levinson, A., Minier, J. (2004). “Trade Liberalization and Pollution Havens.” *Advances in Economic Analysis & Policy*, 3(2).

__________ (2005). Footloose and pollution-free Review of Economics and Statistics, 87, pp. 92–99.

Eickhout, B., van Meijl, H., Tabeau, A., & van Zeijts, H. (2004). “Between liberalization and protection: four long-term scenarios for trade, poverty and the environment.” In *GTAP Conference Paper, gepresenteerd op de 7th Annual Conference on Global Economic Analysis*, Washington, DC. June 2004.

Economist Intelligence Unit, The (EIU) (2016). Basic Data, Kenya. Retrieved on March 23, 2016 from: http://country.eiu.com/kenya.

Elshennawy, Abeer (2011). "Is there a triple dividend effect from a tax on fertilizer use? A computable general equilibrium approach." Working Paper 582, *The Economic Research Forum.* Cairo, Egypt. www.erf.org.eg.

Eskeland, G. S., & Harrison, A. E. (2003). "Moving to Greener Pastures? Multinationals and the Pollution Haven Hypothesis." *Journal of development economics*, 70(1), 1-23.

European Commission (2015a). *Economic Partnership Agreement between the EU and the Eastern African Community (EAC).* European Commission's October 2015 Update. Available online at: http://trade.ec.europa.eu/doclib/docs/2009/january/tradoc_142194.pdf.

__________ (2015b). *Kenya – EU Trade relations.* Delegation of the European Union to Kenya. Available online at: http://eeas.europa.eu/delegations/kenya/eu_kenya/trade_relation/index_en.htm.

FAPDA (Undated). *Agricultural Policy Frameworks in Kenya*. The Food and Agriculture Policy Decision Analysis (FAPDA) program. Available online at: www.fao.org/fileadmin/templates/fapda/Kenya-Policy.

Feenstra, Robert C. (2004). "The Heckscher–Ohlin Model". *Advanced International Trade: Theory and Evidence.* Princeton: Princeton University Press. pp. 31–63. ISBN 0-691-11410-2.

Feridun, M., Ayadi, F. S., & Balouga, J. (2006). "Impact of Trade Liberalization on the Environment in Developing Countries: The Case of Nigeria." *Journal of Developing Societies*, 22(1), 39-56.

Frankel, J.A. Rose, A.K., (2005). "Is trade good or bad for the environment? Sorting out the causality." *Review of Economics and Statistics,* 87 (2005), pp. 85–91.

Gallagher, K. (1999). *Pollution intensive industry in Mexico under NAFTA: model and empirical evidence*. Praxis, 15, 1-15.

Gallagher, K., & Ackerman, F. (2000). "Trade liberalization and pollution intensive industry in developing countries: A partial equilibrium approach." *Assessing the Environmental Effects of Trade Liberalisation Agreements: Methodologies.* Paris: OECD, 267-277.

Geary, Roy C. (1950). "A Note on 'A Constant-Utility Index of the Cost of Living'". *Review of Economic Studies.* 18 (2): 65–66. JSTOR 2296107.

Githaiga, Cicilia W. (2013). *Policy, Legal & Institutional Framework for Environmental Governance in Kenya.* National Environmental Management Authority (NEMA), Government of Kenya. Available online at the Partnerships for Sustainable Business Development in Kenya – SUSBIZ Kenya website at: http://susbizkenya.org/.

Government of Kenya (1965). *African Socialism and Its Applications to Planning in Kenya*. Sessional Paper No. 10. Nairobi: Government Printer.

Government of Kenya (2008). *Kenya Vision 2030: the country's development programme over the 2008-2030 period.* Launched on June 10, 2008. Popular Version is available online at: http://www.vision2030.go.ke/wp-content/uploads/2015/12/ Vision2030_Abridged%20(Popular%20Version).pdf.

__________ (2010). *National Climate Change Response Strategy*. Ministry of Environment and Mineral Resources. Email: psoffice@environment.go.ke. Website: www.environment.go.ke.

__________ (2013). *(i) National Environment Policy, 2013; (ii) National Climate Change Action Plan, 2013 -2017*. Ministry of Environment and Mineral Resources. Email: psoffice@environment.go.ke. Available online at: www.environment.go.ke.

__________ (2014a). *Draft National Climate Change Framework Policy*. Version of 22 September 2014. Email: psoffice@environment.go.ke. Website: www.environment.go.ke.

__________ (2014b). *Economic Survey, 2014*. Kenya National Bureau of Statistics. http://www.knbs.or.ke/index.php?option=com_phocadownload&view=category&id=107:economic-survey-publications&Itemid=1181.

__________ (2015a). *Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC).* National Environment Management Authority (NEMA), Government of Kenya, 2015. Electronic version available online at: http://unfccc.int/essential_background/library/items/3599.php?rec=j&priref=7814#beg.

__________ (2015b). *Economic Survey, 2015*. Kenya National Bureau of Statistics. http://www.knbs.or.ke/index.php?option=com_phocadownload&view=category&id=107:economic-survey-publications&Itemid=1181.

__________ (2015c). *Datasets*. Provided to the author by the Kenya National Bureau of Statistics, including: Kenya's detailed Micro Social Accounting Matrix (SAM), 2009 and detailed balanced Supply and Uses Tables (SUT) consisting of 151 products by 81 industries.

Green Belt Movement (2015). *Wangari Maathai*, The Nobel Peace Prize. http://www.greenbeltmovement.org/wangari-maathai/the-nobel-peace-prize (Accessed: December 25, 2015).

Grether, J. M., & De Melo, J. (2003). *Globalization and Dirty Industries: Do Pollution Havens Matter?* (No. w9776) National Bureau of Economic Research.

Grossman, G. M., & Krueger, A.B. (1991). "Environmental Impacts of a North American Free Trade Agreement." *NBER Working Paper Series*, National Bureau of Economic Research, Cambridge, MA.

_________ (1993). *Environmental Impacts of a North American Free Trade Agreement*, in P. Garber, ed., The U.S.-Mexico Free Trade Agreement, Cambridge MA: MIT Press, 13-56.

Grossman, G. M., & Krueger, A.B. (1995). "Economic Growth and the Environment." *Quarterly Journal of Economics*. 353-377.

Gumilang, H., Mukhopadhyay, K., & Thomassin, P. J. (2011). "Economic and environmental impacts of trade liberalization: The case of Indonesia." *Economic Modelling*, 28(3), 1030-1041.

Haufler, A., Pflüger, M. (2004). "International commodity taxation under monopolistic competition." *Journal of Public Economic Theory*, 6, pp. 445–470.

Hertel (1997). *Global Trade Analysis: Modeling and Applications*, T.W. Hertel (ed.), published in 1997 by Cambridge University Press (https://www.gtap.agecon.purdue.edu/products/gtap_book.asp).

Hettige, H., R. Lucas and D. Wheeler (1992). "The Toxic Intensity of Industrial Production: Global Patterns, Trends, and Trade Policy." *American Economic Review* (Papers and Proceedings) 82, 478-481. Also see: Policy, Research working paper ; no. WPS 1431. Washington, DC: World Bank. http://documents.worldbank.org/curated/en/ 690881468761745598/The-industrial-pollution-projection-system

International Energy Agency (IEA) (2015). *CO2 Emissions from Fuel Combustion*, OECD/IEA, Paris, 2015. Published online at: http://www.iea.org/statistics/ topics/CO2emissions/.

IMAGE team, 2001. *The IMAGE 2.2 implementation of the SRES scenarios. A comprehensive analysis of emissions, climate change and impacts in the 21st century*. RIVM CD-ROM publication 481508018, National Institute for Public Health and the Environment, Bilthoven, the Netherlands.

International Monetary Fund (IMF) (2016). *World Economic Outlook Database*. April 2016 (Date: 03/2016). Available online at: http://www.imf.org/ external/ns/cs.aspx?id=28.

Jaffe, A. B., Peterson, S. R., Portney, P. R., & Stavins, R. N. (1995). "Environmental Regulation and the Competitiveness of US Manufacturing: What Does the Evidence Tell Us?" *Journal of Economic literature*, 33(1), 132-163.

Javorcik, B. S., & Wei, S. J. (2004). "Pollution havens and foreign direct investment: dirty secret or popular myth?." *Contributions in Economic Analysis & Policy*, 3(2).

Jha, V., & Markandya, A. R. Vossenaar (1999). *Reconciling Trade and the Environment: Lessons from Case Studies in Developing Countries*. Cheltenham, UK: Edward Elgar Publishing.

Kågeson, P. (1998). *Growth versus the Environment: Is there a Trade-off?* Dordrecht, The Netherlands; Boston: Kluwer Academic Publishers, c1998.

Kang, Sang In, and Jae Joon Kim (2004). "A quantitative analysis of the environmental impact induced by free trade between Korea and Japan." In *7th Annual Conference on Global Economic Analysis Trade,* Washington DC, pp. 17-19. 2004.

Kant, A. Masiga, H. and Veenstra, E. (2014). *Market Study to Strengthen Economic Cooperation in the Energy Sector.* Final Report (Kenya). Triple E Consulting – Energy, Environment & Economics B.V. info@tripleeconsulting.com.

Karingi, S. N., & Siriwardana, M. (2003). "A CGE model analysis of effects of adjustment to terms of trade shocks on agriculture and income distribution in Kenya." *The Journal of Developing Areas*, v. 37 (1), p. 87-108 (2003) -- issn:0022-037X -- Tennessee State University. http://e-publications.une.edu.au/1959.11/1316.

Kennedy, P. W. (1994). "Equilibrium pollution taxes in open economies with imperfect com- petition." *Journal of Environmental Economics and Management.* Volume 27, Issue 1, July 1994, Pages 49-63.

Kirkpatrick, C., & Scrieciu, S. S. (2008). "Is trade liberalisation bad for the environment? A review of the economic evidence." *Journal of Environmental Planning and Management*, 51(4), 497-510.

Klein, L. R., & Rubin, H. (1947). "A constant-utility index of the cost of living." *The Review of Economic Studies*, 15(2), 84-87.

Kreickemeier, U., & Richter, P. M. (2014). "Trade and the environment: The role of firm heterogeneity." *Review of International Economics*, 22(2), 209-225.

Krugman, P. (1980). "Scale economies, product differentiation, and the pattern of trade." *American Economic Review*, 70, pp. 950–959.

Krutilla, K. (1991). "Environmental regulation in an open economy." *Journal of Environmental Economics and Management*, 20(2), 127-142.

Kuik, O., & Gerlagh, R. (2003). "Trade liberalization and carbon leakage." *The Energy Journal*, 97-120.

Kuik, O., & Verbruggen, H. (2002). "The Kyoto regime, changing patterns of international trade and carbon leakage." In *Environmental Economics and the International Economy* (pp. 239-257). Springer Netherlands.

Kuznets, P., Simon, P., (1955). "Economic growth and income inequality." *American Economic Review*, Volume XLV. March 1955, 1– 28.

Leamer, Edward E. (1995). "The Heckscher–Ohlin Model in Theory and Practice." *Princeton Studies in International Finance*. 77. Princeton, NJ: Princeton University Press. ISBN 0-88165-249-0.

Lee, H., & Roland-Holst, D. (1997). "The environment and welfare implications of trade and tax policy." *Journal of Development Economics*, 52(1), 65-82.

Leontief, W. W. (1986). *Input-output economics*. Oxford University Press on Demand.

Levinson, A., Taylor, M. S. (2008). "Unmasking the pollution haven effect." *International Economic Review*, 2008, vol. 49, issue 1, pages 223-254.

Li, J. C. (2005). "Is there a trade-off between trade liberalization and environmental quality? A CGE assessment on Thailand." *The Journal of Environment & Development*, 14(2), 252-277.

Li, Z., Xu, N., & Yuan, J. (2015). "New evidence on trade-environment linkage via air visibility." *Economics Letters*, Volume 128, March 2015, Pages 72–74.

Lloyd, P. J. (1992). The problem of optimal environmental policy choice. The Greening of world trade issues, Anderson and Blackhurst, (eds.). 49-72.

Lluch, C. (1973). "The extended linear expenditure system." *European Economic Review*, 4(1), 21-32.

Lockwood, B. (2001). "Tax competition and tax co-ordination under destination and origin principles: a synthesis." *Journal of Public Economics*, 81, pp. 279–319.

Löfgren, Hans (1993). "A Stylized CGE Model for Egypt in GAMS", Working Paper 3-1993 in *Economics and Political Science*, American University in Cairo.

__________ (1994). *A brief survey of elasticities for CGE models.* Ford Foundation, Cairo.

Löfgren, Hans, Harris, R. L., & Robinson, S. (2001, 2002). *A standard computable general equilibrium (CGE) model in GAMS* (No. 75). International Food Policy Research Institute (IFPRI). See: http://www.ifpri.org/publication/standard-computable-general-equilibrium-cge-model-gams-0].

Low, P. and A. Yeats (1992). "Do Dirty Sectors Migrate?", in P. Low (ed.), *International Trade and the Environment* (Washington, DC: World Bank), 89–103.

Lucas, R. E., Wheeler, D., & Hettige, H. (1992). *Economic Development, Environmental Regulation, and the International Migration of Toxic Industrial Pollution*, 1960-88 (Vol. 1062). World Bank Publications.

Maskus, Keith E., and Denise Eby Konan (1997). "Trade liberalization in Egypt." *Review of Development Economics*, vol. 1, no. 3 (1997): 275-293.

Managi, S., Hibiki, A., & Tsurumi, T. (2009). "Does trade openness improve environmental quality?" *Journal of environmental economics and management*, 58(3), 346-363.

Manderson, E., & Kneller, R. (2012). "Environmental regulations, outward FDI and heterogeneous firms: Are countries used as pollution havens?." *Environmental and Resource Economics*, 51(3), 317-352.

Markusen, J. R. (1975a). "International externalities and optimal tax structures." *Journal of International Economics*. 1975 Feb 28; 5(1):15-29.

__________ (1975b). "Cooperative control of international pollution and common property resources." *The Quarterly Journal of Economics*, Vol. 89, 618-632.

McAusland, C., & Millimet, D. L. (2013). “Do national borders matter? *Intra*national trade, international trade, and the environment.” *Journal of Environmental Economics and Management,* 65(3), 411-437.

McGuire, M. C. (1982). “Regulation, Factor Rewards, and International trade.” *Journal of public economics*, 17(3), 335-354.

Mukhopadhyay and Thomassin (2010). *Economic and Environmental Impact of free trade in East and South East Asia.* Springer, the Netherlands (2010), p. 209.

Mulatu, A., Gerlagh, R., Rigby, D., & Wossink, A. (2010). “Environmental regulation and industry location in Europe.” *Environmental and Resource Economics*, 45(4), 459-479.

Musila, J. W., & Yiheyis, Z. (2015). “The impact of trade openness on growth: The case of Kenya.” *Journal of Policy Modeling*, 37(2), 342-354.

Nordström, H., & Vaughan, S. (1999). *Trade and Environment*. Special Studies No. 4. Geneva: World Trade Organization.

Norton, R. D., & Hazell, P. B. (1986). *Mathematical programming for economic analysis in agriculture.* Macmillan; London: Collier Macmillan.

Odero, W., Reeves, W., and Kipyego, N. (2015). *Kenya Country Note*. African Economic Outlook. A joint publication of the African Development Bank (AfDB), the Organisation for Economic Co-operation and Development (OECD) and the United Nations Development Programme (UNDP). Available Online At: http://www.africaneconomicoutlook.org/en/country-notes/east-africa/kenya/.

OECD (1993). “Environmental Policies and Industrial Competitiveness.” *The Organisation for Economic Co-operation and Development (OECD).* Paris: OECD Documents.

O'Ryan, R., de Miguel, C. J., & Miller, S. (2005). “A CGE Model for Environmental and Trade Policy Analysis in Chile: Case Study for Fuel Tax Increases.” No. 211, *Centro de Economía Aplicada, Universidad de Chile.*

Panayotou, T., (1993). *Empirical tests and policy analysis of environmental degradation at different stages of economic development.* ILO, Technology and Employment Programme, Geneva.

Pflüger, M. (2001). “Ecological dumping under monopolistic competition.” *Scandanavian Journal of Economics*, 103, pp. 689–706.

Powell, A. A., & Gruen, F. (1968). “The constant elasticity of transformation production frontier and linear supply system.” *International Economic Review*, 9(3), 315-328.

Pyatt, G. and J. I. Round (1979). “Accounting and Fixed Price Multipliers in a Social Accounting Matrix Framework.” *The Economic Journal*, Vol. 89, No. 356. pp. 850-873.

Pyatt, G. and J. I. Round (1985). *Social Accounting Matrices: A Basis for Planning.* The World Bank Symposium, World Bank, Washington DC, U.

Robinson, S. (1989). *Multisectoral models.* Handbook of development economics, 2(884947), 1991. Elsevier.

Robinson, S., Yùnez-Naude, A., Hinojosa-Ojeda, R., Lewis, J. D., & Devarajan, S. (1999). "From stylized to applied models: Building multisector CGE models for policy analysis." *The North American Journal of Economics and Finance*, 10(1), 5-38.

Ronge, E., & Nyangito, H. (2000). *A review of Kenya's current industrialization policy* (No. 3). Kenya Institute for Public Policy Research and Analysis.

Saunders, C., & Cagatay, S. (2004). "Trade and the environment: economic and environmental impacts of global dairy trade liberalisation." *Journal of environmental assessment policy and management*, 6(03), 339-365.

Saunders, C., & Wreford, A. (2005). "Agricultural Trade Liberalisation and Greenhouse Gas Emissions: Modelling the linkages using a partial equilibrium trade model." *Agricultural and Resource Economics Review*, 42(1), 32-41.

Sawhney, A., & Rastogi, R. (2015). "Is India Specialising in Polluting Industries? Evidence from US-India Bilateral Trade." *The World Economy*, 38(2), 360-378.

Semboja, H. H. H. (1994). "The effects of energy taxes on the Kenyan economy: a CGE analysis." *Energy Economics*, 16(3), 205-215.

Shafik, N. (1994). "Economic Development and Environmental Quality: An Econometric Analysis." *Oxford Economic Papers*, 46, 757–773. Retrieved from http://www.jstor.org/stable/2663498.

Shafik, N., Bandyopadhyay, S., (1992). "Economic Growth and Environmental Quality: Time Series and Cross-Country Evidence." *Background Paper for the World Development Report.* The World Bank, Washington, DC.

Shoven, J. B., & Whalley, J. (1972). "A general equilibrium calculation of the effects of differential taxation of income from capital in the US." *Journal of public economics*, 1(3), 281-321.

Stone, R. (1954). "Linear expenditure systems and demand analysis: an application to the pattern of British demand." *The Economic Journal*, 64(255), 511-527.

_________ (1970). *Mathematical models of the economy and other essays*. London: Chapman and Hall.

Strutt, A., & Anderson, K. (2000). "Will trade liberalization harm the environment? The case of Indonesia to 2020." *Environmental and Resource Economics*, 17(3), 203-232.

Subramanian, A. (1992). "Trade measures for environment: A nearly empty box?" *The World Economy*, 15(1), 135-152.

Taylor, Lance (1990). *Socially relevant policy analysis: Structuralist computable general equilibrium models for the developing world.* MIT Press.

Taylor, M. S. (2004). "Unbundling the pollution haven hypothesis." *Advances in Economic Analysis & Policy*, 4 (2) Article 8.

Thurlow, J. (2011). "Consequences of avian flu for growth and poverty: a CGE analysis for Kenya." African Development Review, 23(3), 276-288.

Tobey, J.A. (1990). *The Effects of Domestic Environmental Policies on Patterns of World Trade: an Empirical Test.* KYKLOS, Vol.43, Fasc.2, l9l-209.

Torras, M., & Boyce, J. K. (1998). "Income, inequality, and pollution: a reassessment of the environmental Kuznets curve." *Ecological economics*, 25(2), 147-160.

UN Comtrade (2016). United Nations *Commodity Trade Statistics* Database. http://unctadstat.unctad.org/.

UN ESA (2014). United Nations, Department of Economic and Social Affairs, Population Division (2014). *World Urbanization Prospects*: The 2014 Revision, CD-ROM Edition. Online version available at: https://esa.un.org/unpd/wup/.

UNFCCC (1997). Kyoto Protocol to the United Nations Framework Convention on Climate Change. United Nations Framework Convention on Climate Change, FCCC⁄CP⁄L.7⁄Add1, Kyoto. Available Online At: http://unfccc.int/ kyoto_protocol/ status_of_ratification/items/2613.php.

Walras, L. (1874). *Eléments d'économie politique pure ou théorie de la richesse sociale (Elements of Pure Economics, or the theory of social wealth)*. Lausanne, Paris, 1899.

Wheeler, D., & Martin, P. (1992). "Prices, policies, and the International Diffusion of Clean Technology: The Case of Wood Pulp Production." Chap. 12 in *International Trade and the Environment*, ed. by P. Low, World Bank Discussion Paper 159. Washington D.C.: The World Bank, pp. 197-224.

World Bank (1993). *Development and the Environment.* World Development Report 1992. Washington, DC, World Bank Group. http://documents.worldbank.org/ curated/ en/1993/05/17387636/world-development-report-1992-development-environment.

_________ (2000). *Trade blocs.* A World Bank Policy Research Report. Washington, D.C. : The World Bank. http://documents.worldbank.org/curated/en/2000/08/ 443576/ trade-blocs.

_________ (2016). *World Development Indicators*, Updated Date: 2/17/2016. Available online at: http://data.worldbank.org/country/kenya.

WTO (2016). (i) *The environment: a specific concern; (ii) Trade and environment in the WTO; (iii) The impact of trade opening on climate change; (iv)* and *Under WTO rules, members can adopt trade-related measures aimed at protecting the environment...* World Trade Organization (WTO). Available at: https://www.wto.org/english/.

Zepeda, E., Chemingui, M., Bchir, H., Karingi, S., Onyango, C., & Wanjala, B. (2009). *The impact of the Doha Round on Kenya*. Publishers: Carnegie Endowment for International Peace (CEIP); Kenya Institute for Policy Research and Analysis (KIPPRA); United Nations Economic Commission for Africa (UNECA); and United Nations Development Programme (UNDP). November 04, 2009. Available at: http://www.carnegieendowment.org.

Zhu, X., & Van Ierland, E. (2006). "The enlargement of the European Union: Effects on trade and emissions of greenhouse gases." *Ecological economics*, 57(1), 1-14.

VIII. APPENDICES

8.1. Appendix 1: KenCGE Model – Definition of Sets, Parameters, and Variables

Table 8-1: **KenCGE Model - Alphabetical List of Sets**

<u>Sets</u> --- <u>One</u> – <u>Dimensional</u>

$c \in C$	=	commodities
$c \in CX(\subset C)$	=	commodities with domestic production
$f \in F$	=	factors
$f \in FM\ (\subset F)$	=	sectorally mobile factors
$f \in FS\ (\subset F)$	=	sector-specific factors
$h \in H\ (\subset I)$	=	households
$i \in I$	=	institutions
$i \in ID\ (\subset I)$	=	domestic non-government institutions
$i' \in ID'$	=	ID
$s \in S$	=	sectors/good
$s' \in S'$	=	S
$s \in SN\ (\subset S)$	=	non-tradable sectors/goods
$s \in ST\ (\subset S)$	=	tradable sectors/goods

<u>Sets</u> --- <u>Two</u> – <u>Dimensional</u>

$(f, s) \in MFS$	=	mapping between factors (capital, labor, land) and sectors
$(i, f) \in MIF$	=	mapping between institutions and factors (capital, labor, and land)
$(i \in i') \in MIID$	=	mapping between institutions and domestic non-government institutions

Table 8-2: **KenCGE Model - Alphabetical List of Parameters**

α_s^{xp}	=	shift parameter in the production function
α_s^{xt}	=	shift parameter in the output transformation function
α_s^{q}	=	shift parameter in the composite supply function
α_s^{sc}	=	shift parameter for domestic commodity aggregation function
α_{LSNP}	=	share of nonproduction labor in sector s
α_{LSP}	=	share of production labor in sector s
β_{fs}	=	share parameter for factor f in sector s
γ_s	=	share parameter in the output transformation function
$\bar{\gamma}_s$	=	government demand
δ_{sc}^{sc}	=	share parameter for domestic commodity aggregation function
δ_s	=	share parameter in the composite supply function
$\iota_{s's}$	=	quantity of input s' per unit of output s
$\bar{\iota}_s$	=	investment demand
λ_{fs}^{s}	=	fixed supply of sector-specific factor f in sector s
λ_f^{m}	=	fixed supply of sectorally mobile factor f
λ_{ks}^{s}	=	fixed supply of capital
λ_{LNP}	=	fixed supply of nonproduction labor
λ_{LSP}^{s}	=	fixed supply of production labor
$\lambda_{\text{land Agr}}^{Agr}$	=	fixed supply of land in the agriculture sector

(Table 8-2: **KenCGE Model - Alphabetical List of Parameters**) (continued)

p_s^{wm}	= world import price (US$)
Π	= price index (KSh)
θ_{sc}	= yield of output c per unit of activity a
ρ_s^x	= substitution parameter in the output transformation function
ρ_s^q	= substitution parameter in the composite supply function
ρ_c^{ac}	= domestic commodity aggregation function exponent
σ_s^e	= export tax rate
τ_i^d	= rate of direct tax for institution i
τ_s^i	= indirect tax rate
τ_s^m	= tariff rate
$\emptyset^{lw}$	= transfers to labor from Rest of the World (RoW) (US$)
$\emptyset_i^{ig}$	= transfer to institution i from government (KSh)
$\emptyset_i^{iw}$	= transfer to institution i from RoW (US$)
ψ_{sh}^e	= expenditure share for good s for household h
ψ_{if}^f	= share to institution i from the income of factor f
$\psi_{ii'}^i$	= share to institution i from the income of institution i' (excluding direct taxes to the government)
ψ_i^s	= income share for institution i to savings
ω_s	= weight in price index for good s

Table 8-3: **KenCGE Model - Alphabetical List of Variables**

CD_{sh}^h	= consumption demand for good s from household h
c_{fs}^f	= demand for factor f in sector s
K_{ks}^f	= demand for capital in sectors
L_{LSNP}^f	= wage for non-production labor in sectors
L_{LSP}^f	= demand for production labor
$Land_{Land\ Agr}^f$	= demand for land in the agriculture sector
d_s	= domestic output sold domestically
e_s	= exports
e^g	= government expenditures (KSh)
e_h^h	= consumption expenditures for household h (KSh)
m_s	= imports
p_s^d	= domestic price of domestic output (KSh)
p_s^e	= domestic export price (KSh)
p_s^m	= domestic import price (KSh)
p_s^q	= domestic supply price (KSh)
p_s^{va}	= value-added price (KSh)
p_s^{we}	= world export price (US$)
p_s^x	= market price of domestic output (KSh)
PA_s	= activity price (unit gross revenue) (KSh)
$PXAC_{s\,c}$	= producer price of commodity c for activity a (KSh)
q_s	= domestic supply (from domestic output and imports)
QA_s	= quantity (level) of activity
$QXAC_{s\,c}$	= quantity of marketed output of commodity c from activity a
r	= foreign exchange rate (KSh/US$)
s^w	= foreign savings (US$)

Table 8-3: **KenCGE Model - Alphabetical List of Variables**

t_{if}^{f}	= income transfer to institution i from factor f (KSh)
$t_{ii'}^{i}$	= income transfer to institution i from institution i' (KSh)
v_s	= intermediate demand for good s
w_{f}^{m}	= price of sectorally mobile factor f (KSh)
w_{fs}^{s}	= price of sector-specific factor f in sector s (KSh)
w_{ks}^{s}	= price of capital in sectors
$w_{land\ Agr}^{Agr}$	= price of land in agriculture sector
w_{LSNP}^{s}	= wage for nonproduction labor
w_{LSP}^{s}	= wage for production labor
x_s	= domestic output
y_{k}^{f}	= income of capital (KSh)
y_{LSNP}^{f}	= income nonproduction labor (KSh)
y_{LSP}^{f}	= income of production labor (KSh)
y_{land}^{f}	= income of land (KSh)
y^{g}	= government income (KSh)
y_{i}^{i}	= income of institution i (KSh)

8.2. Appendix 2: Results of the KenCGE Model

Table 8-4: **List of Abbreviations Used In KenCGE Model Results Tables**

EXPERIMENTS	
Abbreviation	**Meaning**
exp1	2009 base-run (not reported in the results, below)
exp2	100% reduction in imports tariffs
exp3	10% increase in energy (petroleum) inputs taxes
exp4	exp2 + exp3

ACTIVITIES / COMMODITIES			
Abbreviation	**Meaning**	**Abbreviation**	**Meaning**
AGRICULTURE		**SERVICES**	
AGRICU	Agriculture	SCONST	Construction
		STRNSP	Transportation
INDUSTRY		SOSERV	Other services
IMINIG	Mining and quarrying		
IMEATP	Meat processing		
IFISHP	Fish processing		
IFRVEG	Fruit and vegetable products		
IOILFT	Vegetable and animal oils/fats		
IDAIRY	Dairy products		
IGMILL	Grain mill products		
IBAKRY	Bakery products		
ISUGAR	Sugar manufactures		
ICOFFE	Coffee processing		
ITEAP:	Tea processing		
IOTFDS	Other food products		
IBEVEG	Beverages products		
ITOBAC	Tobacco products		
ITEXTL	Textiles and clothing		
ILEATH	Leather products		
IWOODP	Wood products		
IPAPER	Paper products		
IPRINT	Printing and reproduction		
IPETRO	Refined petroleum products		
IBCHEM	Basic chemicals		
ICHEMP	Chemical products		
IPHARM	Pharmaceuticals		
IRPLST	Rubber and plastics		
INOMTL	Other non-metal mineral products		
IMETAL	Metal products		
IMEQPT	Machinery and equipment		
IOMANU	Other manufactures		
IPOWER	Power generation/distribution		
IWATER	Water supply and sewerage		

Table 8-5: **KenCGE Model Results –Quantities– % Change From Base-Run**

	Activity output			Aggregate quantity			Quantity of imports		
	exp2	**exp3**	**exp4**	**exp2**	**exp3**	**exp4**	**exp2**	**exp3**	**exp4**
Sectors									
AGRICU	-0.08	0.01	-0.07	-0.08	0.01	-0.07	28.49	-1.16	27.17
IMINIG	-1.06	-0.11	-1.17	-1.06	-0.11	-1.17	3.05	0.02	3.07
IMEATP	0.20	-0.04	0.17	0.16	-0.03	0.14	35.23	-1.77	33.09
IFISHP	0.05	0.14	0.17	-0.04	0.05	0.00	30.51	-1.18	29.15
IFRVEG	0.30	0.54	0.78	0.30	0.54	0.78	22.70	-0.49	22.18
IOILFT	0.55	0.16	0.71	0.72	0.01	0.75	14.82	-0.63	14.17
IDAIRY	0.89	-0.12	0.79	0.89	-0.12	0.79	30.61	-1.36	29.03
IGMILL	0.09	-0.05	0.06	0.09	-0.05	0.06	28.89	-1.52	27.18
IBAKRY	3.65	-0.37	3.33	3.65	-0.37	3.33	29.93	-1.41	28.27
ISUGAR	-1.11	0.02	-1.08	-1.38	0.07	-1.31	26.99	-1.26	25.59
ICOFFE	-0.07	0.06	-0.01	-0.07	0.06	-0.01	32.64	-1.02	31.44
ITEAP	0.21	0.12	0.31	0.21	0.12	0.31	32.99	-1.21	31.56
IOTFDS	-2.75	0.28	-2.48	-1.69	0.16	-1.54	23.50	-1.03	22.39
IBEVEG	0.59	-0.06	0.55	0.59	-0.06	0.55	32.33	-1.51	30.55
ITOBAC	0.64	0.36	0.96	0.64	0.36	0.96	22.94	-0.88	21.97
ITEXTL	-0.12	0.06	-0.06	-0.12	0.06	-0.06	23.14	-0.80	22.28
ILEATH	0.20	0.06	0.25	0.20	0.06	0.25	26.12	-1.06	24.95
IWOODP	-0.61	0.00	-0.61	-0.61	0.00	-0.61	19.05	-0.26	18.80
IPAPER	-1.92	0.10	-1.84	-1.63	0.09	-1.56	8.64	-0.03	8.62
IPRINT	-0.07	0.02	-0.05	-0.07	0.02	-0.05	26.41	-0.37	26.01
IPETRO	0.10	0.01	0.11	0.10	0.01	0.11	6.81	-0.42	6.42
IBCHEM	1.31	0.10	1.41	1.35	0.09	1.44	3.48	-0.04	3.46
ICHEMP	1.23	-0.43	0.86	1.09	-0.31	0.83	14.74	-0.36	14.35
IPHARM	10.69	0.55	11.34	10.69	0.55	11.34	8.21	-0.34	7.86
IRPLST	1.55	0.02	1.60	1.55	0.02	1.60	14.43	-0.53	13.89
INOMTL	0.12	-0.03	0.10	0.07	-0.03	0.05	13.41	-0.07	13.33
IMETAL	-0.18	0.05	-0.13	-0.18	0.05	-0.13	8.22	-0.07	8.15
IMEQPT	0.15	0.03	0.18	0.15	0.03	0.18	2.68	-0.10	2.57
IOMANU	-0.16	0.03	-0.13	-0.15	0.03	-0.12	16.68	-0.54	16.13
IPOWER	0.60	-0.48	0.17	0.60	-0.48	0.17	28.28	1.49	29.89
IWATER	0.20	-0.05	0.16	0.20	-0.05	0.16	0.00	0.00	0.00
SCONST	0.03	0.00	0.03	0.03	0.00	0.03	0.00	0.00	0.00
STRNSP	0.38	-0.33	0.10	0.38	-0.33	0.10	2.62	-0.84	1.84
SOSERV	-0.06	0.06	-0.02	-0.06	0.06	-0.02	3.30	-1.23	2.15

Table 8-5: **KenCGE Model Results –Quantities– % Change From Base-Run** (continued)

Sectors	Quantity of exports			Quantity sold domestically of domestic output			Quantity of goods supplied domestically ("composite supply")		
	exp2	exp3	exp4	exp2	exp3	exp4	exp2	exp3	exp4
AGRICU	0.75	2.21	2.71	-0.17	-0.21	-0.36	2.64	-0.31	2.34
IMINIG	32.09	-0.30	31.73	-7.86	-0.07	-7.92	0.07	0.00	0.07
IMEATP	-10.11	4.37	-6.60	0.22	-0.06	0.18	0.35	-0.06	0.30
IFISHP	-0.97	1.13	0.03	0.45	-0.52	-0.01	3.56	-0.60	3.01
IFRVEG	3.41	1.14	4.41	-2.68	-0.03	-2.71	1.22	-0.10	1.12
IOILFT	16.19	0.80	16.95	-4.05	-0.22	-4.26	6.82	-0.46	6.37
IDAIRY	0.44	2.55	2.74	0.91	-0.26	0.69	2.38	-0.32	2.09
IGMILL	0.86	3.62	4.05	0.08	-0.08	0.02	4.43	-0.31	4.13
IBAKRY	11.55	2.24	13.90	3.60	-0.38	3.27	3.83	-0.39	3.49
ISUGAR	-0.81	2.51	1.40	-1.44	-0.19	-1.60	5.01	-0.45	4.58
ICOFFE	-0.83	0.37	-0.50	1.66	-0.62	1.10	1.79	-0.63	1.23
ITEAP	-0.58	0.51	-0.13	1.93	-0.72	1.27	2.38	-0.73	1.72
IOTFDS	3.46	2.37	5.62	-2.22	-0.07	-2.27	3.23	-0.28	2.96
IBEVEG	-3.13	3.00	-0.51	0.82	-0.25	0.61	2.29	-0.31	2.01
ITOBAC	1.82	0.63	2.37	-2.98	-0.45	-3.38	7.87	-0.64	7.24
ITEXTL	5.42	1.07	6.37	-1.90	-0.27	-2.14	4.04	-0.40	3.66
ILEATH	2.95	1.24	4.07	-0.88	-0.41	-1.23	5.44	-0.57	4.90
IWOODP	16.72	0.56	17.26	-1.40	-0.02	-1.43	0.09	-0.04	0.05
IPAPER	27.91	0.30	28.21	-5.19	0.06	-5.15	0.20	0.02	0.22
IPRINT	4.87	0.91	5.69	-0.19	0.00	-0.19	0.18	-0.01	0.17
IPETRO	31.37	0.67	32.02	-5.63	-0.11	-5.74	2.44	-0.31	2.15
IBCHEM	10.26	0.14	10.40	-12.24	0.01	-12.22	1.21	-0.03	1.19
ICHEMP	18.40	-0.25	18.21	-3.57	-0.33	-3.86	4.01	-0.34	3.68
IPHARM	21.14	0.88	22.18	-6.92	0.01	-6.91	6.64	-0.31	6.32
IRPLST	24.19	0.88	25.17	-2.44	-0.13	-2.55	2.11	-0.24	1.89
INOMTL	15.43	0.02	15.45	-5.07	-0.05	-5.11	0.70	-0.05	0.65
IMETAL	23.85	0.22	24.07	-6.33	0.01	-6.32	0.59	-0.03	0.56
IMEQPT	13.77	0.11	13.87	-11.94	-0.04	-11.98	1.74	-0.10	1.64
IOMANU	17.84	1.01	18.81	-2.55	-0.10	-2.65	2.56	-0.22	2.35
IPOWER	3.77	-5.04	-0.73	0.56	-0.42	0.18	0.79	-0.40	0.42
IWATER	0.00	0.00	0.00	0.20	-0.05	0.16	0.20	-0.05	0.16
SCONST	0.00	0.00	0.00	0.03	0.00	0.03	0.03	0.00	0.03
STRNSP	-2.18	0.27	-1.88	1.22	-0.52	0.76	1.27	-0.54	0.80
SOSERV	-6.49	2.66	-4.21	0.40	-0.14	0.29	0.51	-0.18	0.36

Table 8-6: **KenCGE Model Results –Prices– % Change From Base-Run**

Sectors	Real wage rate for production labor exp2	Real wage rate for production labor exp3	Real wage rate for production labor exp4	Nominal wage rate for production labor exp2	Nominal wage rate for production labor exp3	Nominal wage rate for production labor exp4
AGRICU	1.39	-0.18	1.25	0.65	-0.59	0.13
IMINIG	-6.28	-1.54	-7.69	-6.97	-1.95	-8.71
IMEATP	21.54	-3.34	18.43	20.65	-3.74	17.12
IFISHP	4.11	0.66	4.70	3.35	0.24	3.54
IFRVEG	4.98	1.73	6.56	4.21	1.30	5.38
IOILFT	6.61	0.30	6.94	5.82	-0.12	5.76
IDAIRY	11.27	-1.48	9.89	10.46	-1.89	8.67
IGMILL	5.28	-1.26	4.19	4.51	-1.67	3.04
IBAKRY	20.82	-2.06	18.73	19.94	-2.46	17.41
ISUGAR	1.69	-0.47	1.28	0.94	-0.89	0.16
ICOFFE	2.27	0.81	2.99	1.52	0.39	1.85
ITEAP	7.87	1.88	9.53	7.07	1.46	8.32
IOTFDS	-0.48	-0.10	-0.53	-1.21	-0.52	-1.64
IBEVEG	9.93	-1.12	8.91	9.12	-1.54	7.71
ITOBAC	6.22	0.85	7.03	5.45	0.43	5.84
ITEXTL	2.20	0.23	2.42	1.45	-0.19	1.29
ILEATH	5.29	-0.07	5.29	4.52	-0.49	4.12
IWOODP	-2.37	-0.51	-2.80	-3.09	-0.92	-3.88
IPAPER	-8.96	0.15	-8.84	-9.63	-0.27	-9.85
IPRINT	1.28	0.23	1.50	0.53	-0.19	0.38
IPETRO	9.01	-0.08	9.09	8.21	-0.49	7.88
IBCHEM	12.30	0.12	12.48	11.48	-0.30	11.24
ICHEMP	6.59	-1.48	5.23	5.81	-1.89	4.07
IPHARM	25.80	0.53	26.66	24.88	0.12	25.26
IRPLST	9.89	-0.44	9.64	9.09	-0.85	8.42
INOMTL	8.42	-1.52	7.08	7.62	-1.93	5.90
IMETAL	1.21	0.21	1.43	0.47	-0.21	0.31
IMEQPT	8.67	0.45	9.12	7.87	0.03	7.91
IOMANU	0.42	0.06	0.53	-0.31	-0.36	-0.58
IPOWER	6.44	-2.59	3.98	5.66	-3.00	2.83
IWATER	6.01	-1.08	5.04	5.23	-1.49	3.88
SCONST	3.88	-0.53	3.40	3.12	-0.94	2.25
STRNSP	7.47	-3.56	4.24	6.68	-3.96	3.09
SOSERV	3.50	-0.35	3.17	2.74	-0.77	2.03